

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-255 602

Systems Program for the Analysis of Nonurban, Nonpoint Source Pollutants in the Missouri Basin Region

Midwest Research Inst.

Prepared For
Environmental Protection Agency

May 3, 1973

SYSTEMS PROGRAMS FOR THE ANALYSIS OF NONURBAN, NONPOINT
SOURCE POLLUTANTS IN THE MISSOURI
BASIN REGION

by

A. Eugene Vandegrift
Shen-yann Chiu

Midwest Research Institute
425 Volker Boulevard
Kansas City, Missouri 64110

for the

Office of Water Programs
U.S. Environmental Protection Agency
Suite 906, Lincoln Towers
1860 Lincoln Street
Denver, Colorado

Attn: Mr. Keith Snyder

EPA Contract No. 68-01-0159

MRI Project No. 3572-C

3 May 1973

REPRODUCED BY
**NATIONAL TECHNICAL
INFORMATION SERVICE**
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No. PB-255 602
4. Title and Subtitle Systems Program for the Analysis of Nonurban, Nonpoint Source Pollutants in the Missouri Basin Region		5. Report Date 3 May 73	6.
7. Author(s) A. Eugene Vandergrift and Shen-yann Chiu		8. Performing Organization Rept. No.	
9. Performing Organization Name and Address Midwest Research Institute Kansas City, Missouri		10. Project/Task/Work Unit No. MRI-3572-C	11. Contract/Grant No. EPA-68-01-0159
12. Sponsoring Organization Name and Address Environmental Protection Agency Denver, Colorado Office of Water Programs		13. Type of Report & Period Covered	14.
15. Supplementary Notes See also PB-255 603.			
16. Abstracts A program for the analysis of nonurban, nonpoint source pollutants in the Missouri River Basin was conducted at Midwest Research Institute under the sponsorship of the EPA. The ultimate goal of the program is to develop system models that can be used by EPA to assess the impact of nonpoint source pollutants on the pollution of surface water, and to facilitate long-range planning for pollution control.			
17. Key Words and Document Analysis. 17a. Descriptors *Stream pollution, *Data processing, *Missouri River Basin, Systems engineering, Computer programs, Surveys, Data acquisition, Sites, Land use, Rural areas, Surface waters, Assessments, Water quality, Farm crops, Pesticides, Livestock, Fertilizers, Environmental impacts.			
17b. Identifiers/Open-Ended Terms *Water quality data.			
17c. COSATI Field Group 13 B 9 B			
18. Availability Statement National Technical Information Service Springfield, Virginia 22161		19. Security Class (This Report) UNCLASSIFIED	21. No. of Pages 122p
		20. Security Class (This Page) UNCLASSIFIED	22. Price 5.50/2.25

DISCLAIMER

This report has been reviewed by the Office of Water Programs and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Office of Water Programs, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

PREFACE

This report was prepared and submitted in partial fulfillment of EPA Contract No. 68-01-0159 which was monitored by Mr. Keith Snyder.

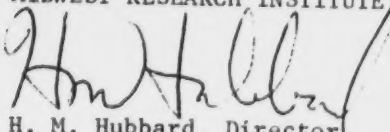
In the program, data related to nonurban, nonpoint sources of pollutants were collected, evaluated, compiled, and organized. The data are now available on computer tape and also in a data bank.

In addition to this report, a User's Manual has been prepared (and is being submitted as a separate document) for the computer programs which were developed to create, update, and use the data storage bank developed during the project. Complete printouts of the data bank (COUNTY MASTER FILE and STATION MASTER FILE) have been forwarded to Mr. Snyder, Mr. Robert V. Brown, and Dr. Marshall Rose. Also, magnetic tapes of the COUNTY MASTER FILE and STATION MASTER FILE were sent to Mr. Snyder.

The work was conducted in the Environmental Sciences Section of the Physical Sciences Division. The report was written by Dr. A. E. Vandegrift and Dr. S. Y. Chiu with assistance from Mr. Richard Salmon, Mr. Duane Dieckman, and Mr. Evan Stewart.

Approved for:

MIDWEST RESEARCH INSTITUTE


H. M. Hubbard, Director
Physical Sciences Division

3 May 1973

TABLE OF CONTENTS

	<u>Page</u>
Summary.	1
Introduction	5
Related Studies	5
Physical Characteristics of the Missouri River Basin. . . .	6
Approach to the Study	8
Report Organization	10
Identification of Data Sources and Collection of Data.	11
Evaluation of Data	17
Organization of Data	21
Data Files.	25
Computer Software	26
Methods for Updating the Data System.	39
Identification of Data by Source.	40
Conclusions.	43
Recommendations.	45
Appendix A - Data Sources Investigated	47
Appendix B - Individual Contacts	77
Appendix C - Water Quality Stations Selected	85
Appendix D - Selection of Important Parameters	93
Appendix E - MRI Station and River Codes	101
Appendix F - Maps Showing County-Watershed Relationships for Subbasins 31 through 42	111

SUMMARY

A program for the analysis of nonurban, nonpoint source pollutants in the Missouri River Basin was conducted at Midwest Research Institute under the sponsorship of the EPA. The ultimate goal of the program is to develop system models that can be used by EPA to assess the impact of nonpoint source pollutants on the pollution of surface water, and to facilitate long-range planning for pollution control.

EPA is deeply concerned about (a) the influence on water quality of substances introduced into surface water courses from the agricultural sector, and (b) the associated policy decisions about their abatement. Specifically, questions are frequently asked about the contribution of fertilizers to nutrient level in waterways, and the value of treatment of waste from point sources for improving water quality if agricultural pollution continues unabated; in both cases careful studies have to be conducted before final answers can be given.

MRI's program has three phases. Phase I (the work conducted to date) involved efforts to (1) provide physical data in order to establish relationships that can be used to predict and assess water quality problems, establish abatement priorities, and determine effects under various conditions; and (2) provide economic base data that can be used for cost projections, economic analyses, incentive development, and EPA policy determination for the various components of nonpoint source pollution. Phase II and Phase III involve development of models, analytical tools, and computer programs that EPA can use in planning and implementing effective pollution-control programs. These analytical tools will allow EPA to choose between various alternatives in carrying out its mandate to improve the water quality in the basin.

This report describes the results accomplished in Phase I of this program. The principal results are highlighted in the following paragraphs.

Determination of Data Needs and Data Sources

An extensive study was conducted to evaluate the types and sources of data affecting the quality of surface waters in the Missouri River Basin. The sources were evaluated with respect to the quantity and quality of the data as well as their accessibility. As a result of our information search, we concluded that data categories should include: water quality, hydrology, climatology, topography, soil classification, land use, livestock distribution, fertilizer use, pesticide use, and demography.

Personal communications were established with national, regional, and local agencies which compiled and/or analyzed these data. The sources explored by MRI include: EPA, USGS, Bureau of Census, USDA, NOAA, Corps of Engineers, and State Pollution, Health and Agriculture Agencies.

We found that the majority of data needed are available in a computer-processible form, such as STORET (water quality and stream flow data), Census of Agriculture (land use and livestock data), Conservation Needs Inventory (land use and soil classification), and NOAA (precipitation data). Other necessary data not available on tapes were also collected, or estimated. Pesticide data were obtained through work with the county agents.

Preliminary Data Evaluation

This task was conducted concurrently with the collection of data, to establish our confidence that the collected data would be useful for model development. Several two-parameter correlations were prepared for this purpose. We also evaluated the various data parameters whenever possible by comparing the same piece of data from different data sources.

Data Compilation

The significant achievement of this study has been the compilation of all pertinent data in a logical fashion, which allows easy access for whatever analysis might be desired.

Data are collected and classified on the basis of three separate systems: data on water quality and hydrology come from the stream stations at which they are monitored; data for slope, soil classification, land use, livestock distribution, fertilizer use, and pesticides use are available by counties; and precipitation data are from each weather station. We related all data to a common base--the watershed. To achieve this, the county-watershed relationships and county-weather station relationships were determined and utilized to transform data from counties or weather stations into the watershed. The data systems developed directly relates water quality parameters to all physical, economical and climatological parameters. The present file has water quality data and hydrological data for 1968, 1969, and 1970, and land use data for 1969. However, provisions were made for updating when new data become available.

Two major computer files were produced for this program. The COUNTY MASTER FILE has one record for each of the 438 counties in the Missouri River Basin. Records for each county consist of data in their land use, fertilizer and pesticide application, soil classification, livestock distribution, topography, and climatology. The STATION MASTER FILE contains information unique to an individual station and the watershed which impacts that station. In this file, the station location, the water quality and hydrological data, the area and physical characteristics of the watershed, and all information available for counties in the watershed as recorded in the COUNTY MASTER FILE are compiled. Two hundred thirty-three water quality stations were selected in this program. These stations were chosen on the basis of their locations, and the type and frequency of their measurements.

Report Organization

The document submitted herein consists of two parts: the Final Report and the Data Bank. The Final Report describes the accomplishment of Phase I efforts, including the result of literature search and personal contact, and types and characters of data collected, evaluation of data, the methods of data compilation, and use of these data for development of analytical tools. The Data Bank consists of COUNTY MASTER FILE and STATION MASTER FILE, magnetic tapes containing the information of these two files, and the User's Manual. Also included are the more extensive raw data files (magnetic tapes) from which the Master Files were compiled.

Conclusions and Recommendations

Principal conclusions of Phase I are:

--Methodology developed to treat nonurban situations is unique and useful for similar studies in other areas of the nation.

--Preliminary evaluation indicates that data collected are sufficient in their quality and quantity for the development of system models.

--Available data are sufficient for economic projections.

On the basis of these conclusions, we recommend that Phases II and III of this program should be initiated to further evaluate the data and to

develop system models which relate water quality and hydrologic parameters to physical, climatic, and economic factors. These models will allow EPA to make economic and planning decisions concerning nonurban, nonpoint pollution sources in the Missouri River Basin.

INTRODUCTION

EPA is deeply concerned about the amount and proportion of agriculturally generated pollution in running streams and rivers, and needs more factual information on these matters as a basis for policy decisions affecting, for example, the use of fertilizers or pesticides in a given area. As a result of this concern, EPA has sponsored an investigation by Midwest Research Institute (MRI) to determine if data exist which will supply the factual information EPA needs, and then (assuming the data exist) to compile and organize these data into a computer data bank. This report describes MRI's effort to collect, analyze, and organize data regarding nonurban nonpoint sources of pollutants in the Missouri Basin region. Background on why the study is needed, where it was done, and how it was done, as well as, how the report is organized are presented in the remainder of the Introduction.

Related Studies

State and local officials as well as the GAO* have contended for some time that agriculture-related pollutants from natural runoff affect the water quality of the Missouri River to a far greater extent than do effluents from primary-treated municipal and industrial waste along the main stem. Any expected enhancement in water quality from secondary treatment, they say, will be obscured by the magnitude of pollutants from agricultural sources.

EPA has, therefore, initiated this study to obtain data that will allow it to relate water quality to land use practices or other economic and physical parameters. The objectives of the program discussed in this report were:

1. To provide economic base data that could be used for cost projections, economic analyses, incentives development, and Environmental Protection Agency policy determination of the various components of nonpoint source pollution.
2. To provide physical data regarding climate, topography, and land use practices in order to establish relationships that can be used to predict and assess water quality problems, establish abatement priorities, and determine effects under various conditions.

* "Alternatives to Secondary Sewage Treatment Offer Greater Improvement in Missouri River Water Quality," GAO Report B-125042, 6 January 1972.

3. To combine (1) and (2) to provide guides regarding the likely effects of changes in economic structure or land use practices on water quality.

Several earlier studies were conducted elsewhere to develop models for urban runoff. However, only one or two attempts have been made to investigate nonpoint, nonurban pollutant sources.* Studies have also been conducted to collect and organize certain of the data that were needed for the present study: for example, the Type I Comprehensive Framework Study of the Missouri River Basin conducted by the Missouri Basin Inter-Agency Committee (MBIAC). However, these data collections have not been extensive enough for the purposes of the present program, and have been used mainly as the basis of projections of water- and land-related resource needs. EPA has also recently initiated a number of studies to apply existing detailed water quality models to important stretches of various river basins around the country. Although such studies are being initiated for the upper South Platte River, the upper Mississippi River, the Iowa-Cedar River Basin, etc., they will not emphasize non-urban, nonpoint pollution problems. We therefore believe that this program is the first step in the development of a methodology which will facilitate the evaluation of water quality management alternatives in cases where nonurban, nonpoint factors are significant.

Physical Characteristics of the Missouri River Basin

The land area which is drained by the Missouri River and its tributaries consists of approximately 530,000 sq miles with all except about 10,000 sq miles in the United States. This land area covers approximately one-sixth of the contiguous United States, and includes all or parts of 10 different states. The basin contains about 113 million acres of tillable cropland, about 175 million acres of grassland, approximately 45 million acres of woodlands and forest, and approximately 7 million acres which have been utilized for urban or nonurban development purposes.

There are several different ways of subdividing the Missouri Basin, and we have chosen that used by the Office of Water Data Coordination (OWDC). The OWDC divides the basin into 13 subbasins designated subbasins 31 to 43. These subbasins cover the northwestern portion of Missouri, the

* "Agricultural Pollution of the Great Lakes Basin," EPA/WQO, Report No. 13020-07/71. "Determination of Land Runoff Effects on Dissolved Oxygen by Mathematical Modeling," Douglass-Wallace, Ph.D. Thesis, University of Iowa, August 1971.

northern portion of Kansas, all of Nebraska, the western half of Iowa, the southwestern tip of Minnesota, most of North and South Dakota, the eastern portion of Montana, and the northwestern portions of Colorado and Wyoming.

The Missouri River itself flows 2,315 miles from its formation at the junction of the Jefferson, Gallatin, and Madison rivers in Montana to its mouth just above St. Louis, Missouri. Seven major tributaries flow into the Missouri from the south and west. These are the Yellowstone, the Cheyenne, the Niobrara, the Platte, the Kansas, the Osage and the Gasconade rivers. Five tributaries flow in from the north and east. These are the Milk River, the James, the Big Sioux, the Grand and the Chariton. The Missouri discharges an average of 83,000 cfs at its mouth, but its maximum record flow has been as great as 900,000 cfs and the minimum flow as low as 4,000 cfs.

There are three major physiographic divisions within the Missouri River--the interior highlands, the interior plains, and the Rocky Mountain System. Within the basin, the Rocky Mountain System division includes parts of the Northern Rocky Mountains, Middle Rocky Mountains, Wyoming Basin, and Southern Rocky Mountains provinces. The Interior Plains division includes parts of the Great Plains and the Central Lowlands. Distinct topographic features within the Great Plains provinces are the Black Hills of South Dakota and Wyoming and the Sand Hills of Nebraska. That portion of the Interior Highlands division within the basin is characterized by its Ozark Plateau provinces.

In the Missouri River Basin, climate has a great influence on the living habits and socioeconomic structure of the people. Obviously, it has a strong influence upon the basic agricultural industry, primarily because of the seasonal and variable regimen of precipitation, temperature and wind.

The climate within the basin is determined largely by the interaction of three great air masses which have their origins over the Gulf of Mexico, the northern Pacific Ocean, and the northern polar regions. They regularly invade and pass over the basin throughout the year, with Gulf air tending to dominate the weather in the summer and polar air dominating in the winter. This seasonal domination of the air masses, and the frontal activity caused by their colliding with each other, produce the general weather regimens found within the basin. Primarily because of its midcontinental location, the basin experiences weather that is known for its fluctuations and extremes. Also, there

are variations between areas within the basin. Winters are relatively long and cold over much of the basin, while summers are fair and hot. Spring is cool, moist and windy; autumn is cool, dry and sunny. Averages are misleading, for seldom does "average weather" actually occur. Instead, weather tends to fluctuate widely around the annual averages, with the occurrences and degrees of fluctuation being unpredictable.

The average annual precipitation varies from about 40 in. in parts of the Rocky Mountains and in southeastern parts of the basin, to as low as 6-12 in. immediately east of the Rocky Mountains. Complicating the annual variations, there is a wide variation in the basin pattern of monthly precipitation.

Winds in the basin are the rule rather than the exception, particularly in the plains area. Average wind velocities at 10 miles/hr are prevalent over much of the basin. In the plains area, strong winds accompanied by snow sometimes create blizzard conditions, dangerous to both man and livestock. High winds that occasionally prevail during periods of high temperature, decrease the moisture, destroy crops, and desiccate range land within a few days. Parts of the basin, particularly the southeast, are subject to cyclonic and tornadic winds that occasionally do considerable damage.

Approach to the Study

To meet the program objectives, the following data categories were investigated: water quality, climatology, hydrology, land use, topography, soil classification, livestock distribution, pesticide use, and fertilizer use. (We also have demographic data available if they are needed.) In developing a logical plan of attack, this program was originally divided into five tasks:

1. Determination of available data sources;
2. Collection of available data;
3. Compilation and cross-correlation of data;
4. Evaluation of data; and
5. Preparation of data bank.

The steps necessary to accomplish these tasks are presented in Figure 1.

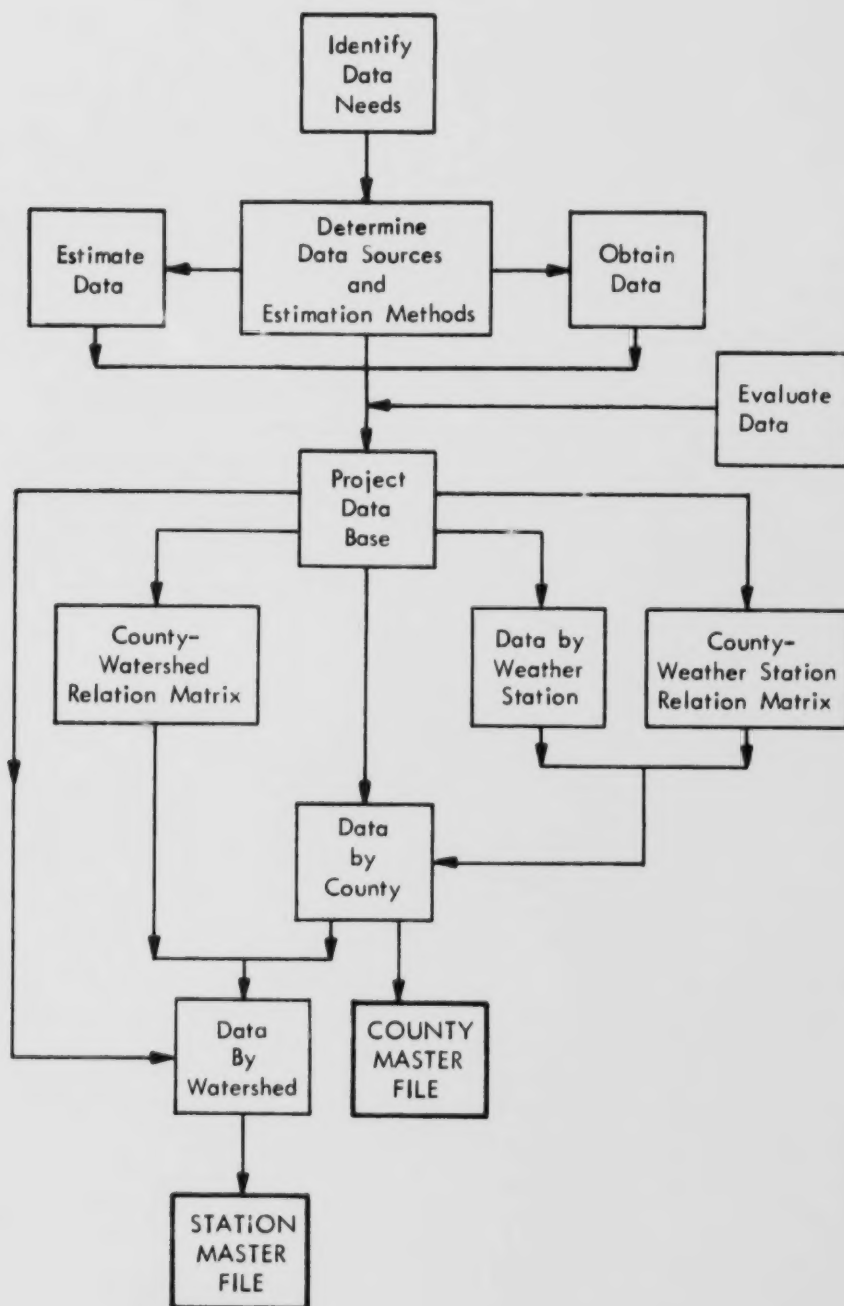


Figure 1 - Phase I Program Flow Sheet

After the first 8 weeks of the program, it was apparent that substantially more data existed on magnetic tapes than had previously been supposed. Therefore, in conference with the Project Officer, it was decided that the most effective use of available resources would be to concentrate on development of the data base and a data storage formatting system. Using this approach, it was felt that we would have substantial quantities and types of data on automatic data processing tapes in an easily accessible format that could then be analyzed with ADP systems on a much more sophisticated scale than the originally anticipated two-parameter correlations.

The effect of this action was to set Tasks 3 and 4 at a later point in the system following Task 5. Although the ultimate impact on resources in terms of this contract was not known at that time, it was decided that if parts of Tasks 3 and 4 could not be completed with available resources, the resulting ability to upgrade and extend the analyses more than offset any reductions in these two tasks.

One of the significant problems with the data that we found available was that physical data, such as water quality parameters, were measured on the basis of the water quality station location, land use parameters such as livestock distribution, fertilizer use, and soil types, are all on the county basis; while climatological data, such as rainfall amount, are available on the basis of weather stations. For the purpose of data correlation it was necessary to relate all data to a single base. The data storage system we developed is based on watersheds. This system will be explained more fully in "Organization of Data" of this report.

Report Organization

In the subsequent sections of this report, we discuss how the needed data sources were identified and the methods of data collection that we used; the method of organizing the data; the data-storage techniques; the conclusions that we have reached; and our recommendations.

IDENTIFICATION OF DATA SOURCES AND COLLECTION OF DATA

The data categories selected for this program, as given in the Introduction, were selected on the basis of needs for the development of empirical models or correlations. Such correlations can be used to develop a systematic methodology, which, in turn, will facilitate the evaluation of water quality management alternatives in cases where non-urban, nonpoint factors are significant. In other words, the data needs were based on requirements to develop appropriate models, analytical tools, and computer programs to be used by EPA in planning and implementing effective pollution control programs.

Information was gathered from a search of literature, both published and unpublished, and by telephone contact, and personal visits with knowledgeable persons in government agencies including EPA, USGS, NOAA, USDA (SCS, ASCS), OWDC, Corps of Engineers, Bureau of Reclamation, Bureau of Census, Missouri Basin Inter-Agency Committee (MBIAC), and state and local health, pollution, and agriculture agencies, and in universities. From this extensive search, we found a large number of data sources including inventories which contained data pertinent to this program. For each inventory or other information source, we conducted a thorough investigation into the types of data available, method of data storage, techniques that could be used to retrieve the data, and, if possible, methods by which the data were obtained (i.e., sampling and analysis techniques). Information resulting from these investigations was subsequently used in selecting the data sources for input to our data system.

We identified numerous sources of water quality data for the Missouri River Basin. Among these were the EPA, the MBIAC, USGS, the Army Corps of Engineers, the Bureau of Reclamation, state water pollution control agencies, water- and waste-treatment plants, etc. At each of these sources, we interviewed persons in charge, studied their data, and evaluated its utility and availability for this program. We found, for example, that treatment plant data are generally stored in state files or by the treatment plants themselves, and that these data are generally not published and must be copied manually from their files. On the other hand, the EPA's STORET system is in computer-processible form and collects data from many (although not all) of these sources and is the single most comprehensive source of water quality data available. We, therefore, elected to use STORET as the primary source of water quality data for this program.

An extensive investigation was also made of land-use data sources including the Bureau of Census, the Bureau of Reclamation, U.S. Department of Agriculture--the Statistical Research Service, the Agricultural Stabilization and Conservation Service, the Forest Service and the Soil Conservation Service, and state departments of agriculture. Again appropriate persons in each agency were contacted and samples of data from each of these sources were investigated. Based on the accessibility, estimated accuracy, and completeness of the data, we selected the Census of Agriculture (1969) (the Bureau of Census), and Conservation Needs Inventory (1958 and 1967) (the Soil Conservation Service), as the primary sources of land-use data for this program.

We found that some data needed in this study had not been collected or were still in the form of maps, tables, graphs, etc. In these cases, special efforts were made: (1) to contact people who might have, or be able to estimate, the needed data; and (2) to search the literature for information from which the needed data could be generated using various estimating techniques.

From the type of storage and availability, we classified data availability into three different categories. The first category includes those which are available on magnetic tapes, such as NOAA (precipitation), Conservation Needs Inventory (1958 and 1967), Census of Agriculture (1969), and STORET. Magnetic tapes of these inventories were obtained, from which, the needed data retrieved. Data in the second category are those available in published literature in the form of tables, graphs, maps, etc., from which the needed data were tabulated and transformed into computer processible form. Data included in this category are stream channel slope--from topographic maps and river profiles; rainfall intensity--from NOAA's Rainfall Frequency Atlas; Soil Infiltration Rate--from soil maps; and county fertilizer use data (for the states: Colorado, Iowa, Kansas, Missouri, and Nebraska)--from materials published by each state department of agriculture. The third category of data includes those which did not exist in any repository, such as county pesticide use data, and fertilizer use data for counties in North and South Dakota, Wyoming, Montana, and Minnesota. In these cases, we contacted county agents and other knowledgeable persons to obtain their estimates of pesticide or fertilizer usage. We also developed methods to estimate these data to check results obtained from county agents, etc., or to use when no other estimate was available.

Data from all sources were retrieved, transformed, developed, or estimated, and subsequently organized and stored in a data bank which consists, on one hand, of information on natural factors and man's activities which contribute nonpoint source pollution, and, on the other hand, of water quality and hydrologic information of the entire 10-state Missouri River Basin. This data bank which will facilitate the analysis of cause-and-effect relationship is described in detail including its organization and format in the section, "Organization of Data."

Table I presents a list of the major sources from which we obtained the data. This table also indicates which parameters were obtained from which data source.

Details describing the literature we searched, people and agencies that we contacted, data inventories that we have investigated, contacting methods for county agents, and methods that we developed to estimate data are given in Appendices A and B. Of the several data sources listed in Appendix A, we used those where the information was most accessible, complete, accurate or was the only source available.

Important points concerning the data collected in this program are:

1. The data collected, including water quality, stream flow, land use, precipitation, etc., are primarily for the year of 1969. Selection of this year was made based on the fact that:

- (a) considerably more water quality data are available for this year than any of the previous years, and (b) it is the year when the most recent Census of Agriculture was made.

2. We selected a total of 233 water quality stations which collected suitable data for this program. The majority of these stations measured streamflow in addition to the water quality.

3. There are 438 counties in the basin. For each of them we were able to collect or estimate data for land use, soil type, ground slope, rainfall intensity, livestock distribution, fertilizer use, and pesticides use.

4. There are 2,448 climatological stations in the 10 states in the basin which have precipitation data available for this program.

TABLE I
TYPES AND MAJOR SOURCES OF DATA

Data Category	Data Source		Parameters
	Agency	Format	
Water Quality	EPA	STORET ^A /	Sediment, Nutrient, Organic, Pesticides, and Microorganism Concentrations
Hydrology	EPA	STORET ^A /	Streamflow Rate
Climatology	NOAA	Precipitation ^A / Data Tape	Seasonal and Yearly Precipitation
Topography	NOAA	Rainfall Frequency Atlas of the U.S.	Rainfall Intensity
	SCS	Conservation Needs Inventory, 1967 ^A /	Land Slope Percent Class
	USGS	Topographic Map	Main Channel Slope
	Corps of Engineers	River Profile	Main Channel Slope
Soil Classification	SCS	Conservation Needs Inventory, 1967 ^A /	Soil Capability Class, Soil Erosion Class, and Soil Name
	SCS	Hydrologic Soil Group	Soil Index
	Missouri Basin Inter-Agency Committee	Infiltration Data	Soil Infiltration Rate
Land Use	Bureau of Census	Census of Agriculture, 1969 ^A /	Crop Acreage

TABLE I (Concluded)

Data Category	Data Source		Parameters
	Agency	Format	
Livestock	Bureau of Census	Census of Agriculture, 1969 ^a /	Cattle, Hogs, Sheep, Horses, Chickens, and Commercial Feedlots
Fertilizer Use	Bureau of Census	Census of Agriculture, 1969 ^a /	Lime Usage
	State Department of Agriculture	Fertilizer Tonnage Report, 1969	Nitrogen, Phosphoric Pentoxide, and Potash Usages
Pesticides Use	County Agent	MRI Questionnaire	Insecticides and Herbicides Usages

^a/ Available in computer-processible form.

EVALUATION OF DATA

The data obtained in this program were evaluated by two methods: (1) a comparative evaluation of the same data from different data sources; and (2) an evaluation based on simple, two-parameter correlations of data collected.

We evaluated the various data parameters whenever possible by comparing the same piece of data from different data sources. The crop acreage and number of livestock, which constitutes one of the most important data categories in this program, were reported independently by the state departments of Agriculture and the Bureau of Census. Data from these two sources were compiled and compared, and did not show significant deviation. This comparison increases our confidence in the reliability of the land use data available. We have randomly selected data from nine counties in the basin, which are shown in Table II.

For those data which could not be obtained from multiple sources, regression methods combined with physical judgment were used to assess the quality of available data.

As an example of those regression techniques, correlation between BOD in the streams (lb/day) and number of cattle per county were successfully developed. The equation for this relation is:

$$\text{BOD} = 4.19 \times 10^{-4} (\text{Number of Cattle})^{1.45}$$

The coefficient of correlation for this relation is quite high at 0.86.

Several other correlations were also satisfactorily developed:

- Nitrate Concentration versus Fertilizer Use
- Sediment Yield versus Land Use
- Fertilizer Use versus Crop Value
- Pasture Land versus Herbicide Use
- Pesticide Use versus Fertilizer Use

Details of these correlations have been presented in the Phase IA report of this program.

TABLE II

COMPARISON OF STATE DATA WITH CENSUS OF AGRICULTURE (1969) DATA

County State Source	Logan Colorado State (1966) Census	Buena Vista Iowa State (1969) Census	Clay Kansas State (1970) Census	Vernon Missouri State (1968) Census	Powder River Montana State (1969) Census	Antelope Nebraska State (1969) Census	Emmons N. Dakota State (1970) Census	Kingsbury S. Dakota State (1970) Census	Niobrara Wyoming State (1968) Census
Corn	51 54	194 207	26 21	61 72	0.5 0	227 207	44 34	153 132	0.8 1
Sorghums	13 6	0.3 0	101 91	28 29	NA 0	11 8	NA 1	3.5 5	NA 0
Wheat	244 270	0 0	125 129	50 35	41 35	2 2	167 169	34 29	14 13
Soybean	NA 0	144 142	8 8	97 85	NA 0	23 19	0 0	NA 0	NA 0
Hay	93 86	20 19	45 35	57 48	87 82	105 80	190 135	83 74	63 54
Cattle	162,800 185,955	NA 67,635	58,000 52,202	62,800 63,527	70,000 73,842	90,000 94,560	69,000 66,834	80,000 67,629	48,400 56,827
Hogs	7,200 12,442	NA 162,768	39,700 33,713	22,800 31,097	400 471	82,970 78,510	12,000 6,358	44,300 38,802	NA 1,478
Chickens	NA 14,859	NA 96,364	166,000 124,054	NA 24,468	6,500 3,027	105,000 61,571	38,000 35,540	75,000 40,104	NA 2,279
Sheep	4,400 5,355	NA 13,318	1,500 1,922	NA 1,826	56,000 53,122	5,300 5,080	1,020 1,710	32,400 29,990	59,900 61,058

Unit: Crop - square mile; livestock - head.

NA: Not Available.

Pertinent correlations developed by other researchers were also located. Streamflow equations* developed by USGS for each state in the basin have been obtained. These equations are the result of multiregression analysis of the type required to develop models relating water quality to other physical and economic parameters. The existence of these equations, plus the correlations obtained in the program, raises the probability that we will be able to use available data to develop meaningful models for the Missouri River Basin.

* See Appendix D.

ORGANIZATION OF DATA

Data collected in this program can be classified on the basis of three separate systems: data on water quality, and hydrology come from the stream station at which they were monitored; data for slope, soil classification, land use, livestock distribution, fertilizer use, and pesticides use are available by counties; and precipitation data are from each weather station. For the purpose of data correlation, it is necessary to relate all data to a common base. The base we chose was the watershed. Consequently, data which are based on county or weather station must be transformed into watershed data.

The data transformation was accomplished in six steps:

1. Identification of the weather stations in each county.
2. Selection of the water quality stations.
3. Definition of the boundary and area of watersheds which directly influence the measurement of the selected water quality stations.
4. Location of the counties and the portions of the counties covered by the watershed.
5. Allocation of the county data into the county-watershed intersections (hereafter called "zones"), and
6. Summation or averaging of the data for each zone in the watershed to form the data base for that watershed.

Step 1 was done by referring to the NOAA's publications* which show the locations of all weather stations in the basin. Information obtained at this step was subsequently used to determine the county precipitation data by averaging those from the stations in the county.

Steps 2, 3, and 4 were carried out as follows:

An inventory of water quality stations in the basin was retrieved from the STORET. Selection of stations was made based on their locations, and the type and frequency of their measurements. As a result, 233 stations were selected.

* For example, "Climatological Data" Annual Summary for Colorado, 1969. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Environmental Data Service.

Each of these selected stations was located on the maps prepared by the OWDC.* From the maps, the boundary of watershed which related to the selected station, and the boundaries of zone in the watershed, were determined.

The OWDC divides the Missouri River Basin into 13 subbasins and designates them 31 to 43. Maps were available for each of these subbasins.

Figure 2 presents the map for subbasin 43, which was subdivided as described. The dots indicate the particular water quality stations. The watershed boundaries and county lines are also indicated. Maps for subbasins 31 to 42 are presented in Appendix F.

The watershed and zone areas were determined by tracing a planimeter on the OWDC watershed maps. In addition to the area, average distances from centroid of zone to the respective monitoring station were also determined. The distance information will be used when the effect of river self-purification is to be investigated. For example, the BOD monitored at a water quality station is more strongly influenced by the zones that are closer to the station.

For each of these stations, the identification code given by MRI (details of which are discussed in Appendix E) and codes used by different agencies, the location, the area, and the composition of the watershed in terms of zones, have been determined and recorded. Table III shows an example of these records.

The selected station, 5720006, is in subbasin 32 and is on the Smokey Hill River near Russell, Kansas. The watershed for this station includes 100 square miles of Russell County, 330 square miles of Ellis County, 200 square miles of Rush County, and 57 square miles of Ness County. The drainage basin for this station has an area of 6,945 square miles which includes the above described watershed and the watersheds for the immediate upstream stations 5720001 (on the Smokey Hill River) and 5723001 (on the Big Creek), respectively. The code and the distance to the next downstream station (5720011) are also recorded. All this information was stored in computer and subsequently used to construct our data system.

The approach we took to allocate county data into the zones (Step 5) is based on the assumption that these data are uniformly distributed in

* "Catalog of Information on Water Data - Maps Showing Locations of Water Quality Stations," Edition 1970, U.S. Department of Interior, Geological Survey, Office of Water Data Coordination.



Figure 2 - Station-Watershed-County Relationships for Subbasin 43

TABLE III

STATION INFORMATION RECORD

County-Basin Records

MRI Station Code: 5720006 Stream: Smoky Hill River
 Tributary Rank: 3 Location: Russell, Kansas
 Lat.-long.: 38 46 36 - 98 51 16
 STORET Station No.: 06864000 Agency Code: 112WRD
 OWDC W.Q.S. No.: 50232
 OWDC S.W.S. No.: 5770
 S.W.S. No.: 0686400 Agency Code: 112WRD
 Sub-Subbasin: 32-G

Total Tributary Area: 6,965 Square Miles (including immediate watershed area and watershed area of next upstream stations)

Immediate Watershed Area:

County	State	Code	Zone Area (sq miles)	Distance (miles)
Russell	Kansas	20167	100	8
Ellis	Kansas	20051	330	30
Rush	Kansas	20165	200	36
Ness	Kansas	20135	57	62

The Next Upstream Selected Stations

MRI Code	Agency Code and Number	Stream	Distance (miles)
5720001	112WRD 06862700	Smoky Hill River	46
5723001	112WRD 06863500	Big Creek	34

The Next Downstream Selected Station

MRI Code	Agency Code and Number	Stream	Distance (miles)
5720011	112WRD 06864500	Smoky Hill River	36

each county.* Data such as crop acreage, number of cattle, fertilizer use, etc., for each zone were calculated through multiplication of each parameter value by the percentage of zone area in the county. Data for watershed were then obtained by summing zone data of all zones located in the watershed (Step 6). For data such as ground slope, soil erosion class, precipitation amount, etc., we assumed that each zone in the same county has the same data value. A weighted average (with respect to area) of these data types for all zones in the watershed was then determined to arrive at the data for the watershed (Step 6).

Data Files

Based on the need for development of a data system in this phase, and for use in subsequent statistical and system analysis, two major computer files were produced, and these constitute our data report.

COUNTY MASTER FILE: The first file, called the COUNTY MASTER FILE, consists of 728 characters per county record, with one record for each county in the Missouri Basin. The information in the county record includes location, land characteristics, land use (crops, fertilizer, livestock and poultry, etc.). For this report, the COUNTY MASTER FILE will contain data for 1 year, 1969. It is anticipated that county records for years other than 1969 could be developed in the same format.

There are four major sources for the data in the COUNTY MASTER FILE. The first data source is from manual input. Information relating to location, identification, fertilizer use, herbicide-insecticide-fungicide use, for example, was obtained from various sources, coded on the data sheets, and keypunched into cards for use in generating those data elements in the county record.

The second data source is the Conservation Needs Inventory tapes. These tapes were carefully reviewed to identify their unique data contents, and selected data elements will be extracted from them to provide county

* We felt that for overall planning purposes on a large segment of the country such as the Missouri River Basin, the accuracy of this apportionment technique may be sufficient. As future work on correlations proceeds, this assumption should be critically evaluated. In localized areas it can have substantial impact and should be corrected before decisions are made on that local area. Adequacy of the apportionment technique and correction can be assessed and made by consulting individuals in each county who have the best knowledge of their county in this regard; e.g., the county agent or county assessor.

record information. Examples of these data are soil classes, land resource area and region, soil names, watershed, and slope and erosion classes.

The third data source is the Census of Agriculture tapes. These files provided data relating to land use such as crops grown and livestock.

The last data source is the NOAA tapes, providing precipitation data.

STATION MASTER FILE: The second file to be developed for this project is the STATION MASTER FILE. This file, consisting of 1,196 characters per station record, contains information unique to an individual station and the area which impacts that station.

There are three data sources for this file. The first, manual input, consists of data elements relating to station identification and location, area, channel slope, etc. Data sheets were designed, data extracted from various sources, keypunched, and a card file containing these intermediate data developed.

The second data source is the STORET system. This source is used to provide water quality data, hydrologic data, and statistics relative to these data, for each of the stations which have been selected.

The third data source is the COUNTY MASTER FILE described previously. The STATION MASTER FILE will contain data for each of the COUNTY MASTER FILE records which impact the station area, and in proportion to the percentage of the county area within the watershed.

Both of these master files are developed by means of COBOL routines, due to the data manipulation and sorting required in file construction. However, the data element values are expressed in formats which will permit their use in FORTRAN routines. This capability will enable a much broader use of these files for future correlation and other statistical activity.

The complete software developed in this program to generate the two master files is discussed in the next section.

Computer Software

The computer programs required for this study consist largely of programs designed to create a unique data bank from various data sources. For the preparation of reports from the created data bank, only two

programs are used: (1) NPSPSTMD, which writes the station master report, and (2) NPSPCTYD, which writes the county master report.

The programs used with appropriate data sources are as follows:

Manual Input:	NPSPGMF1
	NPSPGAL1
	NPSPGSM1
	NPSPGCM1
	NPSPFPC1

Census of Agriculture:	NPSPCOA1
------------------------	----------

Conservation Needs Inventory:	NPSPCN12
-------------------------------	----------

NOAA:	NPSPNOA1
-------	----------

STORET:	NPSPSTR1
---------	----------

Utility Programs:	NPSPCOA3
	NPSPCN14
	NPSPGAL4
	NPSPGAL6
	NPSPCAL1
	NPSPGSM3
	NPSPCTS2
	NPSPCTS3
	NPSPNOA3
	NPSPFPC3
	NPSPSTR3
	NPSPCOA4

Sort Programs:	NPSPCOA2
	NPSPCN11
	NPSPCN13
	NPSPNOA2
	NPSPFPC2
	NPSPGAL2
	NPSPGAL3
	NPSPGAL5
	NPSPGAL7
	NPSPGSM2
	NPSPSTR2
	NPSPCTS1

An abstract of each program is presented in the following sections.

NPSPSTMD: This program reads the STATION MASTER FILE and creates a report for each MRI station in the Missouri River Basin. The report reflects the pertinent data within the following major categories:

1. Location
2. Land characteristics
3. Land use (acres)
4. Water quality data (averages)
5. Crop data
6. Fertilizer and pesticide data (tons)
7. Livestock and poultry
8. Contributing counties (up to 100)

The data furnished within each of the above categories are as follows:

1. Location
 - a. Stream name
 - b. Location
 - c. County
 - d. State
 - e. Latitude
 - f. Longitude
 - g. Downstream station
 - h. Distance to downstream station
 - i. MRI station number
 - j. STORET station and agency number
 - k. USAS station and agency number
 - l. OWDC WQ station number
 - m. OWDC SW station number
 - n. OWDC sub-subbasin number
 - o. Total watershed area

2. Land characteristics

- a. Main channel slope
- b. Slope percent class
- c. Soil erosion class
- d. Soil infiltration
- e. Soil index
- f. Rainfall intensity
- g. Total precipitation in inches for each season and the year
- h. Soil capability classes for the eight types

3. Land use (square miles)

- a. Land area
- b. Total cropland
- c. Pasture/grazing
- d. Woodlands
- e. Irrigated

4. Water quality data (averages) for each season and the year

- a. Temperature (°C)
- b. Dissolved oxygen (mg/liter)
- c. Biochemical oxygen demand
- d. Nitrogen
- e. Dissolved solids
- f. Nitrate
- g. Phosphate
- h. Suspended solids
- i. Sulfate
- j. Chloride
- k. Herbicides
- l. Insecticides
- m. Fungicides
- n. Streamflow
- o. Total coliform
- p. Fecal coliform
- q. Dissolved oxygen (percent saturation)
- r. Temperature (°F)
- s. Turbidity (Jackson units)
- t. Turbidity (ppm as silicon dioxide)
- u. Phosphorus, wet method (mg/liter as P)
(for details, see Table A-1 in Appendix A).

5. Crop data

- a. Corn
- b. Sorghums
- c. Wheat
- d. Other grains
- e. Soybeans
- f. Hay
- g. Cotton
- h. Peanuts
- i. Tobacco
- j. Potatoes
- k. Vegetables
- l. Berries
- m. Orchards
- n. Other crops
- o. Greenhouses

6. Chemical fertilizer data (tons) - by half year and
pesticide data (tons) - by year

- a. Total nitrogen
- b. Total P_2O_5
- c. Total K_2O
- d. Lime
- e. Herbicides
- f. Insecticides
- g. Fungicides

7. Livestock and poultry

- a. Cattle and calves - total - feedlots - stock in lots
- b. Hogs - total - hog lots - hogs in lots
- c. Chickens - total - chicken houses - chickens in houses
- d. Sheep
- e. Horses and ponies

8. Contributing counties

- a. Each county that shares in the watershed of this station is listed, showing the county area, and percent of the county area in the watershed, and the distance to the station.

NPSPCTYD: This program reads the COUNTY MASTER FILE and creates a report for each county in each state within the Missouri River Basin. The report reflects the pertinent data within the following major categories:

1. Location
2. Land characteristics
3. Land use
4. Crop data
5. Fertilizer data and pesticide data
6. Livestock and poultry

The data furnished within each of the above categories are as follow:

1. Location
 - a. County
 - b. State
 - c. Watershed
 - d. Land resource area
 - e. Land resource region
2. Land characteristics
 - a. Slope percent class
 - b. Soil erosion class
 - c. Rainfall intensity
 - d. Total precipitation (all seasons and the year)
 - e. Soil name
 - f. Soil capability classes
3. Land use
 - a. Land area
 - b. Total cropland
 - c. Pasture and grazing
 - d. Woodlands
 - e. Irrigated

4. Crop data

- a. Corn
- b. Sorghums
- c. Wheat
- d. Other grain
- e. Soybeans
- f. Hay
- g. Cotton
- h. Peanuts
- i. Tobacco
- j. Potatoes
- k. Vegetables
- l. Berries
- m. Orchards
- n. Other crops
- o. Greenhouses

5. Fertilizer data by half year and pesticide data by year

- a. Total nitrogen
- b. Total P_2O_5
- c. Total K_2O
- d. Lime
- e. Herbicides
- f. Insecticides
- g. Fungicides

6. Livestock and poultry

- a. Cattle and calves - total - feedlots - stock in lots
- b. Hogs - total - hog lots - hogs in lots
- c. Chickens - total - chicken houses - chickens in houses
- d. Sheep
- e. Horses and ponies

NPSPQMF1: This program will read the various cards created manually and write them onto a magnetic tape. This provides data to the STATION MASTER FILE and the COUNTY MASTER FILE that are not available from other sources. The purpose is to provide all card input for the system from a central file in an easily accessible form. There are 10 different input types defined as follows:

Type Number

Description

- | | |
|----|--|
| 1. | State name and state number |
| 2. | County data <ul style="list-style-type: none">a. State and county codesb. Maximum 30 min rainfallsc. Soil typed. County areae. County name |
| 3. | Station location and identification <ul style="list-style-type: none">a. MRI station numberb. State and county codec. Latitude of stationd. Longitude of statione. Stream namef. Location |
| 4. | Station cross-reference list <ul style="list-style-type: none">a. MRI station numberb. STORET station numberc. STORET agency numberd. OWDC water quality station numbere. OWDC surface water station numberf. USGS station numberg. USGS agency number |
| 5. | Zone definition <ul style="list-style-type: none">a. MRI station numberb. County - (up to 100 entries)<ul style="list-style-type: none">1. State and county code2. County area3. County - distance to station |

Type Number

Description

- | | |
|-----|---|
| 6. | Hydrological sequence |
| | a. MRI station number |
| | b. Downstream MRI station number |
| | c. Mileage to downstream station |
| 7. | Watershed slope and soil characteristics |
| | a. MRI station number |
| | b. Main channel slope |
| | c. Soil infiltration rate |
| | d. Soil index |
| | e. Map number and location |
| 8. | Applied fertilizer by county by half year |
| | a. State and county code |
| | b. Half year code |
| | c. Total nitrogen |
| | d. Total P ₂ O ₅ |
| | e. Total K ₂ O |
| 9. | Pesticide data |
| | a. State and county code |
| | b. Insecticide |
| | c. Herbicides |
| | d. Fungicides |
| 10. | NOAA station - state county cross-reference |
| | a. State and county code |
| | b. NOAA stations (up to 30) |

NPSPGAL1: This program reads the tape created in NPSPGMF1 and extracts the data Types 2 and 5 onto intermediate data files for sorting. The sorted files will be used by NPSPGAL4 for county allocation data. NPSPGSM2 will sort Type 5 records and NPSPGAL3 will sort Type 2 records.

NPSPGSM1: This program reads the tape created in NPSPGMF1 and extracts the data Types 3, 4, 5, 6, and 7 onto intermediate data files for sorting. The sorted files are used by NPSPGSM3 in the creation of the STATION MASTER FILE. NPSPGAL2 sorts the selected records into station sequence.

NPSPGCM1: This program reads the tape created in NPSPGMF1 and selects data Types 1 and 2 for the creation of the COUNTY MASTER FILE.

NPSPFFPC1: This program reads the tape created in NPSPGMF1 and extracts the data Type 8 onto an intermediate data file for sorting. The sorted file is based in NPSPFFPC3 to add the fertilizer data into the COUNTY MASTER FILE. NPSPFFPC2 sorts the selected records into state and county sequence.

NPSPCOA1: This program reads the Census of Agriculture tape (1969) and selects the following data which will be sorted by NPSPCOA2 for inclusion onto the COUNTY MASTER FILE in NPSPCOA3:

1. State
2. County
3. Data year
4. Land area
5. Total crop area
6. Pasture grazing
7. Woodlands
8. Irrigated
9. Total cattle (including dairy cattle)
10. Total hogs
11. Corn
12. Sorghum
13. Hay
14. Cotton
15. Peanuts
16. Tobacco
17. Potatoes
18. Sheep
19. Horses
20. Total chickens
21. Chicken houses
22. Chickens in houses
23. Wheat

24. Other grain
25. Soybeans
26. Greenhouses
27. Vegetables
28. Berries
29. Orchards
30. Other crops
31. Cattle feedlots
32. Cattle in feedlots
33. Hog lots
34. Hogs in lots

NPSPCNI2: This program reads the Conservation Needs Inventory file sorted by NPSPCNI2 and selects the following data which will be sorted in NPSPCNI3 for inclusion with the COUNTY MASTER FILE in NPSPCNS4:

1. Land resource area
2. Land resource region
3. Soil name
4. Watershed
5. Soil classes
6. Slope percent class
7. Soil erosion class

NPSPNOA1: This program reads the NOAA tape and selects the following data which will be sorted by NPSPNOA2 and added to the COUNTY MASTER in NPSPNOA3:

Precipitation data for each season and the total for the years 1968, 1969, and 1970.

NPSPSTR1: This program will read a print image tape created by STORET and reformats the data onto an intermediate data file for sorting by NPSPSTR2. The sorted file will be read by NPSPTR3 for updating the STATION MASTER FILE. The following data and others will be selected from the STORET print image tape:

1. Temperature °C and °F
2. Dissolved oxygen (mg/liter) and (percent saturation)
3. Biochemical oxygen demand (5 days, mg/liter)
4. Total dissolved solids
5. Total suspended solids
6. Turbidity (Jackson units) and (ppm as silicon dioxide)
7. Total nitrogen
8. Nitrate
9. Total phosphate
10. Total phosphorus
11. Chloride
12. Total coliform
13. Fecal coliform
14. Insecticides
15. Herbicides
16. Fungicides
17. Streamflow
(for details see Table A-1 in Appendix A)

NPSPCOA3: This program reads the file created by NPSPCOA1, sorted by NPSPCOA2, and updates the COUNTY MASTER FILE. The fields specified under NPSPCOA1 are the only fields affected. For consistency of units and because the large areas involved lead to extremely large numbers if the areas are given in acres, the data reported on the Census of Agriculture file in acres were converted to square miles in NPSPCOA1.

NPSPCNI4: This program reads the files created in NPSPCNI2, sorted by NPSPCNI3, and updates the COUNTY MASTER FILE with the apposite data. The data fields affected are defined in NPSPCNI2. An error report will be printed to reflect CNI data for counties which do not exist on the COUNTY MASTER FILE.

NPSPGAL4: This program reads the files created by NPSPGAL1, sorted by NPSPGAL2, NPSPGAL3 and allocates county area, county area for the station and percent of county area for the station and writes the allocation data onto a magnetic tape which is sorted by NPSPGAL5 and used by NPSPGAL6. A report will be written reflecting the data generated with an "*" flagging any fields in error.

NPSPGAL6: This program reads the zone master created in NPSPGAL4 sorted into station sequence by NPSPGAL5 and accumulates the zone areas in each record. The sum of the zone areas by station will be the station area which will be written into each record. The output file will be a disk file to be sorted by NPSPGAL7 into county, state sequence.

NPSPGAL1: This program reads the allocation file created by NPSPGAL6, sorted by NPSPGAL7, and the COUNTY MASTER FILE. The allocation data for each county are used in generating the zone master file. An error report is written reflecting:

1. No allocations for county records and/or
2. No counties for allocation records.

NPSPGSM3: This program reads the file created in NPSPGMF1 and the sorted file created by NPSPGSM2 and generates the STATION MASTER FILE. An error report is written for each station which does not have the necessary data.

NPSPCTS2: This program reads the zone master file created by NPSPCAL1, sorted by NPSPCTS1, and accumulates the zone records by station and writes the apposite county data to an intermediate data file used in NPSPCTS3.

NPSPCTS3: This program reads the intermediate file created in NPSPCTS2 and updates the STATION MASTER FILE created in NPSPGSM3. An error report is written, reflecting: (a) data for which a station master record does not exist; and (b) station master records without county data.

NPSPNOA3: This program reads the intermediate file created by NOSPNOA1, sorted by NPSPNOA2, and updates the COUNTY MASTER FILE. An error report is written to show records selected for which a county master record does not exist.

NPSPFPC3: This program reads the intermediate file created in NPSPFPC1, sorted by NPSPFPC2, and updates the COUNTY MASTER FILE. An error report is written reflecting the data selected for which a county master record does not exist.

NPSPSTR3: This program reads the intermediate file created by NPSPSTR1, sorted by NPSPSTR2 and updates the STATION MASTER FILE. An error report is written for the data records for which no station master record exists.

NPSPCOA4: This program reads the Census of Agriculture tape and creates a report showing the amount of fertilizer (in tons) used by county in Minnesota and Montana (while fertilizer use data for counties in other states were obtained from other data sources, see Appendix A). This will be used to manually input these data with the fertilizer data.

Methods for Updating the Data System

To insure the utility of the data system which has been developed during this program, it has been designed to facilitate the updating of the many parameters in the system. A description of the step-by-step procedure to be followed in updating the system is given below. The detailed operating procedures for this updating will accompany the computer cards and tapes when they are submitted to EPA.

The data necessary to complete the COUNTY MASTER FILE come from four unique sources. The data necessary to complete the STATION MASTER FILE come from one unique source in addition to the complete COUNTY MASTER.

Creation of the COUNTY MASTER FILE:

Manual data: The initial phase of creating the COUNTY MASTER FILE is done by one program which reads manually prepared data writing onto a magnetic tape which is the original County Master. The information loaded during this step is fixed and normally will never change.

Conservation Needs Inventory: The data read from the Conservation Needs Inventory files normally will remain static and therefore they are not kept by year. The data from CNI are merged with the COUNTY MASTER.

Census of Agriculture: The Census of Agriculture files provide data to the COUNTY MASTER for the year 1969. Space is available so that when data become available up to five census from the Census of Agriculture data may be saved. The data read from COA files are merged into the COUNTY MASTER for the appropriate year.

NOAA: The NOAA provides data to the COUNTY MASTER for the years 1968, 1969, and 1970. Space is available for two more years of the NOAA data. The data read from the NOAA file are merged into the COUNTY MASTER for the appropriate year.

Updating: Steps for creation of COUNTY MASTER FILE may be run any time new data become available and the program will update the most recent COUNTY MASTER FILE.

Creation of the STATION MASTER FILE:

Manual data: The original STATION MASTER is created from manually prepared data most of which are constant and will be permanent.

STORET: These data are in the same form as a report using STORET except that they are available on magnetic tape. The tape is converted back into valid data which are added to the STATION MASTER FILE for the correct year. The present file has data for 1968, 1969, and 1970 by season and year.

COUNTY MASTER: The data available on the COUNTY MASTER FILE are spread to each watershed region based on the proportion of the county allocated to the region. With the exception of rainfall data, slope percent class and soil erosion class, all data are spread to the watershed based on a county-to-zone area ratio.

Updating: If data in the COUNTY MASTER or STORET have been updated, it must be assured that a proper dispersion of the data to each watershed is maintained. Each change in data for the COUNTY MASTER will necessitate the updating of the STATION MASTER.

Identification of Data by Source

<u>Source</u>	<u>Field Name</u>	<u>Description</u>
Manual Data	MRI Station Code	Card Type 3
	OWDC Map and Basin	Card Type 7
	State and County	Card Type 3
	State Name	Card Type 1
	County Name	Card Type 2
	Latitude and Longitude	Card Type 3
	Stream Name	Card Type 3
	Location	Card Type 3
	STORET Station and Agency Codes	Card Type 4
	OWDC Water Quality Station Number	Card Type 4
	OWDC Surface Water Station Number	Card Type 4
	USGS Station Code	Card Type 4

<u>Source</u>	<u>Field Name</u>	<u>Description</u>
Census of Agriculture (1969)	Downstream Station	Card Type 6
	Distance to Downstream Station	Card Type 6
	Main Channel Slope	Card Type 7
	Soil Infiltration Rate	Card Type 7
	Soil Index	Card Type 7
	County Code-Each County	Card Type 5
	in Watershed	
	County Total Area-Each County	Card Type 5
	in Watershed	
	County Distance to Station-Each	Card Type 5
	County in Watershed	
	Rainfall Intensity	Card Type 2
	Land Area	
	Total Farmland	
	Total Crop Area	
	Total Other Land	
	Pasture Grazing	
	Harvested Cropland	
	Woodlands	
	Other Cropland	
	Irrigated Other Farmland	
	Corn	
	Sorghum	
	Wheat	
	Other Grain	
	Soybeans	
	Hay	
	Cotton	
	Peanuts	
	Tobacco	
	Potatoes	
	Vegetables	
	Berries	
	Orchards	
	Other Crops	

<u>Source</u>	<u>Field Name</u>	<u>Description</u>
	Greenhouses	
	Total Cattle	
	Cattle Feedlots	
	Cattle in Feedlots	
	Total Hogs	
	Hog Lots	
	Hogs in Lots	
	Sheep	
	Horses	
	Total Chickens	
	Chicken Houses	
	Chickens in Houses	
	Lime	
Conservation Needs Inventory (1969)	Soil Name	
	Slope Percent Class	
	Erosion Class	
	Soil Class Area by Class and Subclass	
	Watershed	
	Resource Area	
	Resource Region	
STORET	Parameters Listed in Table A-1 of Appendix A	
Manual Data	Nitrogen	
	P ₂ O ₅	
	K ₂ O	
	Herbicides	
	Insecticides	
	Fungicides	
NOAA (1968, 1969, and 1970)	Rainfall	Amount for quarters and year

CONCLUSIONS

The objectives of Phase I of this study (that portion of the overall program covered by this report) were to collect, evaluate, and compile the physical and economic base data for the analysis of nonurban, nonpoint, source pollutants in the Missouri River Basin. The results of our study lead to the following major conclusions: (1) we have developed a unique and extremely useful data allocation methodology that is particularly useful for nonurban situations in all parts of the country. We have also catalogued the types and sources of relevant data as well as compiling the data in a form which will be amenable to analysis of all types; (2) the amount of data available for the Missouri River Basin on physical and economic parameters that we investigated are sufficiently large that it should be possible to develop systems models relating nonurban, nonpoint source pollutants to water quality parameters; however, additional evaluation of the collected data should be conducted.

In addition to these major conclusions from the study, there are several other conclusions that can be drawn: (1) the computerized data-storage system developed during this program logically relates county segments to watersheds and should be useful to other government agencies such as USDA and USDI. (2) It is possible to correlate average water quality parameters with land use and other nonwater quality parameters. (This was demonstrated by several two-parameter correlations which were developed in the early stages of the program.) (3) Streamflow equations for all the states in the basin developed by the USGS as a result of multiregression analysis can serve as the basis for the development of basin runoff models. Furthermore, the existence of these equations and of the two-parameter correlations developed in this program, raise the probability that the available data can be used to build useful water quality models for the Missouri River Basin. (4) Relationships between nonwater quality parameters can be developed with the data compiled in this program to make economic projections. For example, fertilizer and pesticide use can be related to land use, agricultural practices to soil type, rainfall amount, and ground slope, etc. (5) For the purpose of obtaining more useful information for improving water quality management planning in the basin, further development of the water quality monitoring network--in terms of station distribution, and types and frequency of measurements at the stations--is needed. The data collected during the present program definitely reflect this need.

RECOMMENDATIONS

On the basis of the conclusions presented in the previous section, several recommendations can be developed. The major recommendation, based on the two major conclusions, is that Phases II and III of this program should be initiated to carry out an in-depth evaluation of both the quantity and quality of data available in the existing data bank. The following analyses are recommended:

1. Assessment of the quality of land use and soil data, e.g., by comparing data from independent sources, and by consulting with knowledgeable individuals (e.g., county agents);
2. Assessment of the quality of hydrological and water quality data, e.g., by statistical comparison among related parameters, and by comparison of existing STORET data with other data which were not available in STORET (e.g., from water and wastewater treatment plants);
3. Identification of interrelationships among different types of variables, e.g., correlation of water quality data with land use data; and
4. Assessment of significance of missing data and use appropriate methods for obtaining or estimating such.

If the results of these analyses show that the amount and quality of both physical and economic data are sufficient, analytical tools should be developed which will allow EPA to make economic and planning decisions concerning nonurban, nonpoint pollutant sources.

In addition to the major recommendation, other recommendations that can be made based on the previous conclusions are: (1) the present data file should be updated whenever new data become available. Updating of the data will provide a base for time series analysis of nonpoint source pollution, as well as allow EPA to update their economic and planning decisions concerning nonurban, nonpoint pollutant sources. (2) The water quality monitoring network in the basin should be improved--for example, the location of stations should be changed so that they are more uniformly distributed in the basin and the types of water quality parameter measured at each station should be reevaluated so that all important data such as pesticide concentrations are measured. This will require a joint effort on national, regional and local pollution control agencies, but this effort should lead to the availability of better information for basin-wide water quality management planning.

APPENDIX A

DATA SOURCES INVESTIGATED

This Appendix presents a discussion of the major data sources that were investigated during the course of this program. The data sources that were actually used in compiling our data bank are presented in "Identification of Data and Collection of Data" of this report.

Tables A-2 through A-11 list all organizations that were contacted to obtain information. Personal contacts that were made are presented in Appendix B.

Water Quality Data

We identified numerous sources of water quality data for the Missouri River Basin. Among these were the Environmental Protection Agency, the U.S. Geological Survey, the Army Corps of Engineers, the Bureau of Reclamation, State Water Pollution Control Agencies, Water-Treatment and Sewage-Treatment plants, etc. Most of the information collected by the treatment plants are stored in state files or by the treatment plants themselves, and not in the computer-processible form. Furthermore, these data are generally not published and must be copied manually from their files. Because we found applicable information from other sources, we did not obtain data from these plants.

The EPA's STORET system collects data from many agencies. It is the most comprehensive source of water quality data and, furthermore, it is in computer-processible form which permits easy access. We, therefore, elected to use it as the primary source of water quality data for this program.

The STORET system has the data for approximately 1,800 stations in the Missouri River Basin and we originally selected, based on the type, frequency, and duration of their measurements, a total of 520 stations. After locating the watershed for these stations from the maps prepared by the OWDC, it was found that some stations are located in close proximity to one another. Also, a number of the stations either do not have surface water stations nearby or do not collect streamflow data themselves. By picking one station when several are located together, and eliminating those stations that do not have flow information (because the streamflow data are essential in our future modeling effort), we reduced the number of the selected stations to 233. Locations of these stations are presented in Appendix C.

In this program, the water quality data retrieved from the STORET for these 233 water quality stations are for those parameters which are most strongly influenced by the nonpoint sources. These parameters

include sediment, nutrients, pesticide level, organic concentration and bacterial density. Table A-1 presents the specifics of parameters retrieved from the STORET system, and their abbreviations appeared in the data report.* We found that most water quality stations measure different sets of water quality parameters. The set of parameters presented in Table A-1 are not necessarily collected by all the stations we selected. We, therefore, elected to have printed, those parameters which are available from the STORET for each station in our data report. Furthermore, we used the frequency of sampling for the majority of stations, and also the needs of our future modeling efforts as a basis for choosing only the seasonal and yearly averages for the years of 1968, 1969, and 1970. Periods of seasons and year are defined as follows:

First season: December (previous year), January, February

Second season: March, April, May

Third season: June, July, August

Fourth season: September, October, November

Year: December (previous year) to November

* STATION MASTER FILE.

TABLE A-1

SELECTED WATER QUALITY PARAMETERS

<u>Code</u>	<u>Parameter Description</u>	<u>Parameter Abbreviation</u>
00010	Water Temperature (degree Centigrade)	TEMP CENT
00011	Water Temperature (degree Fahrenheit)	TEMP FAHN
00060	Stream Flow (cubic feet per second)	FLOW CFS
00070	Turbidity, Jackson Candle (Jackson Unit)	JURB, J.U.
00075	Turbidity, Hellige (ppm as silicon dioxide)	TURB PPMSIO2
00095	Conductivity (micromhos at 25°C)	CNDUTVY MO
00300	Dissolved Oxygen (mg/l)	DO MG/L
00301	Dissolved Oxygen (percent of saturation)	DO SAT PCT
00310	Biochemical Oxygen Demand (mg/l, 5-day-20°C)	BOD5 MG/L
00335	Chemical Oxygen Demand, 0.025N K ₂ CrO ₇ (mg/l)	COD MG/L
00400	pH (standard unit)	PH SU
00500	Total Residue (mg/l)	T RSD MG/L
00505	Total Volatile Residue (mg/l)	TV RSD MG/L
00510	Total Fixed Residue (mg/l)	TFX RSD MG/L
00515	Total Filtrable Residue (mg/l)	TF RSD MG/L
00520	Volatile Filtrable Residue (mg/l)	VF RSD MG/L
00525	Fixed Filtrable Residue (mg/l)	FF RSD MG/L
00530	Total Nonfiltrable Residue (mg/l)	TNF RSD MG/L
00535	Volatile Nonfiltrable Residue (mg/l)	VNF RSD MG/L
00540	Fixed Nonfiltrable Residue (mg/l)	FNF RSD MG/L
00545	Settlable Residue (ml/l)	S RSD ML/L
00600	Total Nitrogen (mg/l as N)	T N MG/L
00605	Organic Nitrogen (mg/l as N)	OG N MG/L
00610	Ammonia Nitrogen (mg/l as N)	AM N MG/L
00615	Nitrite (mg/l as N)	NO2 MG/L N
00620	Nitrate (mg/l as N)	NO3 MG/L N
00630	Nitrite Plus Nitrate, One Determ. (mg/l as N)	NO2&3 MG/L N
00635	Ammonia & Organic Nitrogen, One Determ. (mg/l as N)	AM&OG N MG/L
00650	Total Phosphate (mg/l as PO ₄)	T PO4 MG/L
00655	Poly Phosphate (mg/l as PO ₄)	PL PO4 MG/L
00660	Ortho Phosphate (mg/l as PO ₄)	OT PO4 MG/L
00665	Total Phosphorus, Wet Method (mg/l as P)	T P MG/L
00666	Diss. Phosphorus, Wet Method (mg/l as P)	D P MG/L
00667	Insoluble Phosphorus (mg/l as P)	I P MG/L
00670	Total Organic Phosphorus (mg/l as P)	T OG P MG/L
00930	Dissolved Sodium (mg/l as Na)	D NA MG/L
00931	Sodium Adsorption Ratio	NA ADS RATIO
00935	Dissolved Potassium (mg/l as K)	D K MG/L
00936	Suspended Potassium (mg/l as K)	SUS K MG/L

TABLE A-1 (Concluded)

<u>Code</u>	<u>Parameter Description</u>	<u>Parameter Abbreviation</u>
00937	Total Potassium (mg/l as K)	T K MG/L
00940	Chloride (mg/l as Cl)	CL MG/L
31501	Total Coliform (membrane filter, immed., M-Endo Med, 35°C, /100 ml)	T CLF1/100 ML
31503	Total Coliform (membrane filter, delayed, M-Endo Med, 35°C, /100 ml)	T CLF2/100 ML
31504	Total Coliform (membrane filter, immed., Les Endo Agar, 35°C, /100 ml)	T CLF3/100 ML
31615	Fecal Coliform (MPN, EC Med., 44.5°C, tube. 31614, /100 ml)	F CLF1/100 ML
31616	Fecal Coliform (membrane filter, M-FC Broth, 44.5°C, /100 ml)	F CLF2/100 ML
31673	Fecal Streptococci (membrane filter, KF Agar, 35°C, 48 hr, /100 ml)	F STC1/100 ML
31679	Fecal Streptococci (MF M-Enderococcus Agar, 35 C, 48 hr, /100 ml)	F STC2/100 ML
38260	Methylene Blue Active Substance	MBAS MG/L
70299	Suspended Solids (Residue on Evap. at 180 C, mg/l)	SS MG/L
70300	Total Filtrable Residue (dried at 180 C, mg/l)	TF RSD MG/L
70302	Dissolved Solids - Tons per Day	DS TONS/DAY
70303	Dissolved Solids - Tons per Ac-Ft	DS TONS/A-FT
70324	Suspended Sediment (mg/l)	SUS SED MG/L
71845	Ammonia Nitrogen (mg/l as NH ₄)	AM MG/L NH ₄
71850	Nitrate (mg/l as NO ₃)	NO ₃ MG/L
71855	Nitrite (mg/l as NO ₂)	NO ₂ MG/L
71886	Total Phosphorus (mg/l as PO ₄)	TP MG/L PO ₄
71887	Total Nitrogen (mg/l as NO ₃)	TN MG/L NO ₃
71888	Total Soluble Phosphorus (mg/l as PO ₄)	TSP MG/L PO ₄
71889	Soluble Orthophosphate (mg/l as PO ₄)	SO PO ₄ MG/L

The concentration of insecticides, as denoted by INSECTICIDES in the data report, was taken as the average concentration in whole water sample ($\mu\text{g/liter}$) of the following parameters:

<u>Code</u>	<u>Parameter</u>
39330	Aldrin
39340	BHC
39350	Chlorodane
39360	DDD
39365	DDE
39370	DDT
39380	Dieldrin
39388	Endosulfan
39390	Endrin
39398	Ethion
39400	Toxphene
39410	Heptachlor
39420	Heptachlor Epoxide
39430	Isodrin
39440	NHX
39450	NHP
39460	Chlorobenzilate
39470	Dilan
39480	Methoxychlor
39530	Malathion
39540	Parathion
39550	Chlorothion
39560	Demeton
39570	Diazinon
39580	Guthion
39590	Hept
39600	Methyl Parathion
39610	Phosdrin
39620	Tepp
39750	Sevin
39780	Dicofol
39782	Lindane
39786	Trithion
39790	Methyl Trithion
39800	Imidan
39900	Allethrin
39910	Cinerin
39930	Pyrethrins

The concentration of herbicides, as denoted by HERBICIDES in the data report, was the average concentration of the following parameters in the whole water sample, with unit $\mu\text{g/l}$:

<u>Code</u>	<u>Parameter</u>
39730	2,4-D
39740	2,4,5-T
39760	Silvex
39770	Dacthal (DCPA)
39920	DNOC

Hydrological Data

The principal agencies operating hydrologic stations in the basin are the USGS and the Corps of Engineers. The USGS is the more complete source of hydrologic information. It publishes hydrologic data each year for each state in the basin. Besides being published in tabular form, these data are available in computer-processible form. The USGS operates more than 2,900 surface water stations in the basin with at least 40 stations in every basin state; the single exception is Minnesota. Of these 2,900 stations, over 1,300 report daily discharge and other data less frequently. These data are, for example, stage, peak stage, low flow, cross section, flow duration, flood frequency, coefficient of roughness, time of travel and surface inflow-outflow.

The USGS office in each basin state has developed a streamflow model for that state. These models are based on a regression analysis of all pertinent data, and relate such parameters as rainfall, soil class, drainage area, etc., to the streamflow rate. The number, frequency and location of hydrologic measurements have been sufficient to generate multiple-regression correlations that can be used to predict streamflow. The results of these analyses will be extremely useful to this program. Further details of these are presented in Appendix D.

The Corps of Engineers takes hydrologic data for use in its reservoir and channel straightening work. Most of the information obtained is put into the USGS computer system. The Corps also investigates flood plain for specific watersheds. The results of these investigations are published in reports.

The less important source of hydrologic information for the Missouri River Basin is the River Forecasting Center of National Oceanic and Atmospheric Administration (NOAA) in Kansas City. It has developed long-term hydrographs for 800 subbasins which encompass the entire

Missouri Basin plus an additional quarter million square miles. These subbasins average about 1,000 square miles, but may be as small as 200 to 400 square miles. With these hydrographs and computer models for runoff, NOAA can successfully predict river stages along the Missouri River.

The major concern of this program is the analysis of pollutants from non-point sources. The pertinent hydrologic data are obviously the streamflow rate. Among 233 selected water quality stations, 183 stations collect streamflow data. For 50 other stations, we have identified the nearest gauge stations which have streamflow information to supplement our need. We were able to retrieve these data for 24 of these 50 stations from EPA's STORET system. Data for the remaining 26 gauge stations can be obtained from their respective agencies.

In our data report, the streamflow data are presented in terms of their seasonal and yearly averages for 1968, 1969, and 1970.

Climatological Data

Climatological factors of most importance to our study are rainfall intensity and amount.* Because of the frequency with which these data are taken, much data are available. The principal sources of these data are the U.S. Department of Commerce, National Oceanic and Atmospheric Administrations, Environmental Data Service, Asheville, North Carolina.

Climatological information, such as temperature, precipitation, wind, humidity, etc., for various locales in the country are stored by the NOAA in computer-processible form. From this storage, in addition to the raw data, information resulting from various types of statistical manipulation can also be retrieved, e.g., the total precipitation for a certain geographical area in a defined period of time, or probability that a given rainfall will occur at a certain location for a certain number of times per year, etc.

In the data report of this program, the precipitation data are presented on the seasonal and yearly basis. These data were originally processed by the NOAA from its tapes, and were available from each weather station in the basin. MRI carried out further statistical manipulation on these data to obtain county-precipitation data, which were subsequently presented in the Data Report.

* Wischmeier, W. H., and D. D. Smith, "Rainfall Energy and Its Relationship to Soil Loss," Transaction, Amer. Geoph. Union, 39 (2), 851 (1958).

For the information about the rainfall intensity, we elected to use statistical values of maximum 30-min rainfall that will occur once per year. Intensity data for each county in the basin were also obtained from the NOAA.*

Soil-classification data:

The types of soil directly influence the quality and quantity of pollutant in the surface runoff and the agricultural practices on the lands. Furthermore, the agricultural practices greatly affect the water quality of the streams. Soil-classification data, therefore, are extremely important to the development of models relating water quality to land use.

There are several ways in which soil can be classified. One method is to classify soil by the crops or plants that it will support. There are eight such classifications.

Class 1, few limitations that restrict its use;

Class 2, some limitations that reduce the choice of crops or require moderate conservation practices;

Class 3, severe limitations that reduce the choice of crops or require special conservation practices or both;

Class 4, severe limitations that restrict choice of crops and require careful management;

Class 5, little or no erosion hazard but limitations that are impractical to remove--that limit use largely to pasture, range, woodland, or wildlife food and cover;

Class 6, severe limitations that make it unsuited for cultivation and limit use to pasture, range, woodland, or wildlife;

Class 7, limitations that make it unsuited for cultivation or restrict its use to grazing woodland or wildlife; and

Class 8, limitations that preclude their use for commercial plant production or restrict their use to recreation, wildlife, water supply, and aesthetic purpose.

* "Rainfall Frequency Atlas of the U.S.," U.S. Department of Commerce, Washington, D.C. (1961).

There are subclasses for each of these classes with the exception of Class 1:

Subclass e, erosion--made up of soils where susceptibility to erosion is the dominant hazard and problem in its use;

Subclass w, wetness--made up of soils where excess water is the dominant hazard to limitations in its use;

Subclass s, soil--made up of soils with characteristics in the root zone area which are dominant limitations in its use;

Subclass c, climate--made up of soils where temperature and lack of moisture are limitations in its use.

Information on the preceding type of classification is available from the Conservation Needs Inventory (1967). This inventory classifies the soil on a county-by-county basis for each state in the basin. These data are stored in computer accessible form and we have included them in the data report.

The 1967 Conservation Needs Inventory has data of "Soil Erosion Class" for each county. The Inventory classifies the soils into: little erosion; moderate erosion; severe erosion and gullies; and denoted them with 1, 2, 3, and 4, respectively. Whenever there is no information for a county, a number 0 is shown. We have these data compiled in the data report.

The other method of classifying soil is based on the rate of infiltration of water and takes into account water intake, surface texture, soil permeability, water-holding capacity, and tendency to seal under rain-drop action. The effects of land use, management, slope, vegetation cover, etc., are not considered. The result of this classification is the following six hydrologic soil groupings:

Group 1 is barren rock, shale, and badlands--included are barren and semi-barren badlands, high Alpine mountain areas, and impermeable saline alkaline soil areas. The rate of infiltration is less than 0.05 in/hr.

Group 2 is clay, and claypans, which are slowly permeable and have a slow intake rate of 0.05 to 0.2 in/hr.

Group 3 is moderately fine textured, and has moderately slow permeability and intake of 0.2 to 0.6 in/hr.

Group 4 is medium textured, moderately permeable, and has a moderate intake of 0.6 to 2 in/hr.

Group 5 is moderately sandy, has moderately rapid permeability and an intake of 2 to 6.3 in/hr.

Group 6 is sand and gravel, rapidly permeable, and has a very rapid intake--over 6.3 in/hr.

These types of data are available from the U.S. Department of Agriculture, Soil and Water Conservation Research Division, The Forest Service and the Soil Conservation Service. They are also available from the U.S. Army Corps of Engineers and the U.S. Department of Interior, Bureau of Reclamation. Data from these sources have been summarized in the Missouri Basin Inter-Agency Committee report, and are presented in our data report.

Another type of hydrologic soil grouping which has also been developed by SCS is the soil infiltration index. The computed data (in inches) were based on information on soil type, cover, and agricultural practices, and have been obtained for most parts of the basin. These values were used in system studies of streamflow characteristics of various drainage areas by the USGS. These data also appear in our Data Report.

Land use data:

Land use in the Missouri River Basin can be divided into the following: agriculture, recreation, urban, military, grassland, wildlife areas, forest areas, and water areas. The sources of land use data include the Bureau of Census, the various branches of the U.S. Department of Agriculture--the Statistical Research Service, the Agricultural Stabilization and Conservation Service, the Forest Service and the Soil Conservation Service. Each state also has a Department of Agriculture which collects land-use data. The Department of Interior has land use data in several branches, such as Bureau of Reclamation, etc.

The major source of land use information for this program is the Census of Agriculture for 1969. This census includes detailed land use data by county for each state of the union. The 1969 Census for each state in the basin has become available recently on tape and includes 1964 statistics for comparison with 1969 figures. For each county, data include information about all farms, such as the number, the acreage in the farms, and the land use. The census includes the size of the farms, the farm operator tenure, the farm income and sales, farm production expenses, machinery and equipment, amounts of livestock and poultry and

crops harvested. It also contains some data on irrigation and artificial drainage as well as the agricultural chemicals and commercial fertilizer used. The crops are divided into corn, sorghums, hay, feed, field seeds, strawberries, small grains, soybeans, peanuts, potatoes, tobacco, cotton, vegetables, tree fruit and grapes, nursery and greenhouse products, and forest products. All farms with sales over \$2,500/year were polled, and 50% of farms with sales less than \$2,500/year were polled to obtain this information. Over a 90% return was received.

The other important source of land use information is the Conservation Needs Inventory. Two Conservation Needs Inventories have been published, one for 1958 and the other for 1967. The 1958 inventory contains data on land use and conservation treatment needs by county for the entire United States. Statistics include cropping patterns with yield and projected yield by resource area, soil resource group, and subbasin. The inventory information is correlated with the soil classification data in the Missouri Basin and the correlations are on tapes. The inventory includes all land use except built-up areas and land owned by the federal government.

The 1967 inventory includes all acreage except urban and built-up acres, and all land owned by the federal government other than cropland operated under lease or permit. The inventory was developed from basic data regarding present acreage in major uses and acreage of each land use classified by physical problems affecting use. Estimates of needs for conservation treatment for each major land use were based on the acreages and conditions of the land or the vegetation cover as of the crop year 1967, with due regard to locally applicable information and experience in solving conservation problems.

The 1967 Conservation Needs Inventory is available on magnetic tape for all states in the basin. On a county basis, the data include land capability class and subclass, information on acreage of corn and sorghum, other row crops, close grown crops, summer fallow, total field crops, rotation hay and pasture, hay land, conservation use only, temporarily idle cropland, total tillage rotation, orchards, vineyards and bush fruit, open lands formally cropped and total cropland. Most of these data are based on a 2% sample.

Still another source of information on crops and land use is the Agricultural Stabilization and Conservation Service of the USDA. They have a summary by county of all farms which participate in the ASCS program. This summary represents over 75% of all farms. Through the year 1970, the data cover wheat, cotton, and feed grains, but the 1971 report will

be more extensive--going into more detail and including other grains. The 1971 data will include some information on nonparticipating farms. ASCS uses magnetic tapes for storing their data.

Another data source is the detailed data sheets compiled by counties for the Land Resource Appendix of the Missouri Basin Comprehensive Framework Study. These working papers include land use data for public lands which are not available in the Conservation Needs Inventory. The papers are of value because they present a single source of data on use of these public lands. These data are located otherwise in several government agencies having legal jurisdiction over these lands, i.e., Bureau of Land Management, Forest Service, Bureau of Reclamation, Corps of Engineers, etc. We have these papers in our file.

A final source of land use information is state cropland and livestock data. All states in the Missouri Basin provide an annual or biannual agricultural census and keep a record of major crop acreages and of the number of livestock on farms on a county basis. For most Missouri Basin states, these reports have been compiled for many years (10 to 40 years). While these data are not as detailed as the Conservation Needs Inventory or Census of Agriculture, they represent an annual data source.

Because of their easy accessibility, and nature of the data, the Census of Agriculture (1969) was chosen as the primary source of land use data reported in this program. Data extracted from this document are listed below:

County land area
Total crop area
 Pasture grazing
 Woodlands
 Irrigated
 Corn
 Sorghum
 Wheat
 Other grain
 Soybeans
 Hay
 Cotton
 Peanuts
 Tobacco
 Potatoes
 Vegetables
 Berries
 Orchards
 Other crops
 Greenhouses

From the data tapes of the Census of Agriculture, we also obtained data on fertilizer use and livestock.

Topographic data:

The topographic information needed for this study includes items such as tributary location, drainage area, river mileage, river channel slope, drainage area slope, etc. For drainage area and river mileage, we were able to obtain data from the following agencies:

MBIAC: It has published a report entitled "Condensed Tabulation of River Mileage and Drainage Areas," in 1965, which lists for approximately 900 gauged tributaries: (1) gauge location, (2) mileage above the mouth, (3) noncontributing area, and (4) drainage area. This publication is a supplement to the 1949 edition of the Corps of Engineers' "Missouri River Basin - River Mileages and Drainage Areas."

USGS: Gauge locations and drainage areas are always listed in its annually published "Water Resources Data."

The slope data are probably the most important topographic data for this program. We found that river basin slopes are available from USGS for a very small number of areas in the basin, and were restricted to small tributary areas only. The amount of data was so small that it did not warrant collection. The 1967 Conservation Needs Inventory has data of "Slope Percent Class" for each county, which relate to our needs. We have these data compiled in our Data Report.

Ideally, we need drainage basin slopes for all 233 watersheds selected in this program. However, basin slopes are not available in any publication or from any agency, and would require a tremendous effort if estimated by ourselves.

However, our literature survey indicated that main channel slopes may be used in place of basin slopes. Empirical evidence shows that steep ground slopes are expected to correspond with steep channel gradients; and shallow ground slopes with low stream channel gradients. This relationship has been developed by Horton,* who used the definition:

$$\text{Slope Ratio} = \frac{\text{Channel Slope}}{\text{Ground Slope}}$$

* Horton, R. E., "Erosional Development of Streams and Their Drainage Basins; Hydrophysical Approach to Quantitative Morphology," Geol. Soc. Amer. Bull., 56, 275 (1945).

Strahler* found that, in general, ground slope varies somewhat less than the first power of channel slope, and that the slope ratio tends to range from one-fifth or one-fourth for low values of slopes, up to about one-half for higher values.

We have, therefore, decided to include main channel slope data in our data report. Some of these data are available from the USGS and the Corps of Engineers, and some of them have been estimated from the USGS's topographical maps.

Livestock Data

Data on livestock are available semiannually from the State Agriculture Boards on a county basis. Similar data are also reported in the Census of Agriculture (1969), although less frequently (at 5-year intervals). Due to the computer accessibility, the latter was chosen as the primary source of livestock data in this report. Types of data reported are:

Total cattle
Cattle feedlots
Cattle in feedlots
Total hogs
Hog lots
Hogs in lots
Sheep
Horses and ponies
Total chickens
Chicken lots
Chickens in lots

Sizes of commercial feedlots have been arbitrarily defined as:

Cattle	500 +
Hog	200 +
Chicken	1,600 +

Fertilizer Use Data

The Census of Agriculture reports the total tonnages of fertilizer and lime on a county level. The lime data presented in our report were

* Strahler, A. N., "Equilibrium Theory of Erosional Slopes Approached by Frequency Distribution Analysis," Am. J. of Sci., 248, 673 (1950).

retrieved from this document. For information about fertilizer use, we need more specific information than what is available from the Census. We have been able to obtain desirable data either directly from state agriculture agencies, or from the combination of several information sources.

The fertilizer-use-data compiled in this program are given as to total nitrogen (N), phosphoric pentoxide (P_2O_5), and potash (K_2O) tonnages for the first and second half of 1969. For Colorado, Iowa, Kansas, Missouri, and Nebraska, which report their county usage data semiannually, transformation of their data into the desirable format was straightforward. For Minnesota, Montana, Wyoming, and North and South Dakota, which report data only on a statewide basis, two different methods were adopted to calculate N, P, K data for each county.

North and South Dakota: Fertilizer usage in terms of N, P, K for each county were calculated based on the acreage of major crops in the county and application rate of N, P, K to these crops. County crop data of 1969 were obtained from the reports of the State Department of Agriculture, while the fertilizer application rates to these crops were supplied by persons who have the best knowledge of their state in this regard. They are:

Mr. E. H. Vasey
Extension Soils Specialist
Cooperative Extension Service
Department of Agriculture
North Dakota University
Fargo, North Dakota and

Mr. Paul Carson
Soil Testing
Plant Science Department
College of Agriculture and Biological Sciences
South Dakota University
Brookings, South Dakota

Minnesota, Montana, and Wyoming: These three states have the tonnage data of N, P, K sold for the first and second half of 1969 on a statewide basis. To arrive at fertilizer usage in each county, calculations were carried out as follows:

1. County data from the 1969 Census of Agriculture were used to determine the percentage of the state's total fertilizer which was applied in each county.

2. This percentage was used in conjunction with the state report of fertilizer usage.

The 1969 Census reported total tons of material in some cases and tons of plant nutrients (N, P, K) in others.* The method we adopted for these three states may be more accurate because we know the tons of plant nutrient sold.

Pesticide Data

Pesticides are usually grouped into three major categories: herbicides, fungicides, and insecticides.

Herbicides are used primarily for weed control on crop and pastureland and for brush control on range and pastureland. The Conservation and Land Use Division of ASCS reports the acreage of rangeland, cropland and pastureland treated for control of brush and weeds in each state. This report deals with cost-sharing programs, and is estimated to cover 90% of all herbicide use. During 1969--the last year for which data are presently available--some 2.4 million acres were treated for weed and brush control. Of this total, about 15% were in the 10 states included in the Missouri River Basin, with about 8.5% of the total U.S. Herbicide consumption actually taking place within the basin.

Fungicides are used in substantial quantities for a variety of purposes, although farmers are depending less on chemicals and more on resistant varieties for control of plant pathogens. Some of the major uses of fungicides are for algae control (copper sulfate) and as wood preservatives (creosote and pentachlorophenol). The use of these chemicals is not controlled, and reports of their application are not required. Consequently, only the total quantity of various types of fungicides consumed in the U.S. is available. If we allocate usage according to the total land in farms, the Missouri River Basin is estimated to account for some 23% of the total domestic use of fungicides.

Insecticides are the most controversial of the pesticides. As in the case of herbicides and fungicides, the total U.S. production and consumption are reported annually by ASCS, although the methods, extent and timing of use are not known for any specific area. About 26.5% of the total U.S. insecticide use is believed to occur in the Missouri River Basin. This estimate is based on the area in crops and the insect control recommendations published by the various state agencies.

* Personal communication, Mr. Larry Bourret, Resource Management Specialist, Wyoming Department of Agriculture, Cheyenne, Wyoming.

No reliable data are available on a county basis regarding pesticide applications, other than those published in the Census of Agriculture. The Census reports expenditures of each farmer on a county basis for pesticides for various uses, and the number of acres on which the pesticides were used. However, these data do not constitute the information directly related to our needs.

For the estimation of pesticide applications on a county level, two different methods were considered.

1. A mail survey of county extension agents to determine local pesticide application practices.
2. The following equation, developed from data on a national level and based on typical farm practices for different types of crops:

$$P = 6.5 C + 2.0 S + 1.0 W + 4.0 B + 0.2 H + 8.0 M$$

where P is the total pesticide application for a county, state or region, expressed in pounds; C represents the acres of corn harvested within that area; S , the acres of sorghum harvested; W , the acres of wheat harvested; B , the acres of soybeans harvested; H , the acres of hay, grass and pasturelands; and M , the total acres of all other farm crops harvested. This equation has been discussed in more detail in the Phase IA Final Report of this project.

Though easy to handle, the pesticide equation described above does not take into account the heterogeneity of economical, physical, and land use characteristics of subdivisions in the basin. We, therefore, used a mailed survey as the primary source of pesticide application data on a county basis.

The survey questionnaire for this purpose was prepared and sent to all county agents in the basin. The data surveyed include the quantity of herbicides and insecticides used on crops and on pasture, the most used pesticides in their county, the seasons those substances were applied, and the extra usage of particular insecticides during the past 10 years.

Of the total 409 questionnaires mailed, 114 were returned with the requested data, representing 30% coverage of counties within the basin. Most indicated at least 30% accuracy in their estimations.

These 114 counties (Figure A-1) which responded to our survey are spread randomly but uniformly over the entire basin and should, therefore, be representative of agricultural practices throughout the Missouri River Basin.

For these 114 counties, the pesticide use data that appear in the data report were directly obtained from the survey. For those counties which did not answer the survey, usage data were estimated by using the insecticide and herbicides application rate per acre of cropland. The pesticide application rates were calculated by averaging the application rates of the counties in the same land resources subregions,* which returned the survey. This figure was multiplied by the total cropland acreage to obtain the amount of pesticides applied.

From the results of the county pesticide survey, we reached a conclusion that 85% of the herbicides and 99.6% of the insecticides were applied to the cropland. We, therefore, chose to estimate pesticide use based on crop acreage alone.

* U.S. Department of Agriculture, Soil Conservation Service, Agriculture Handbook 296 (1965).

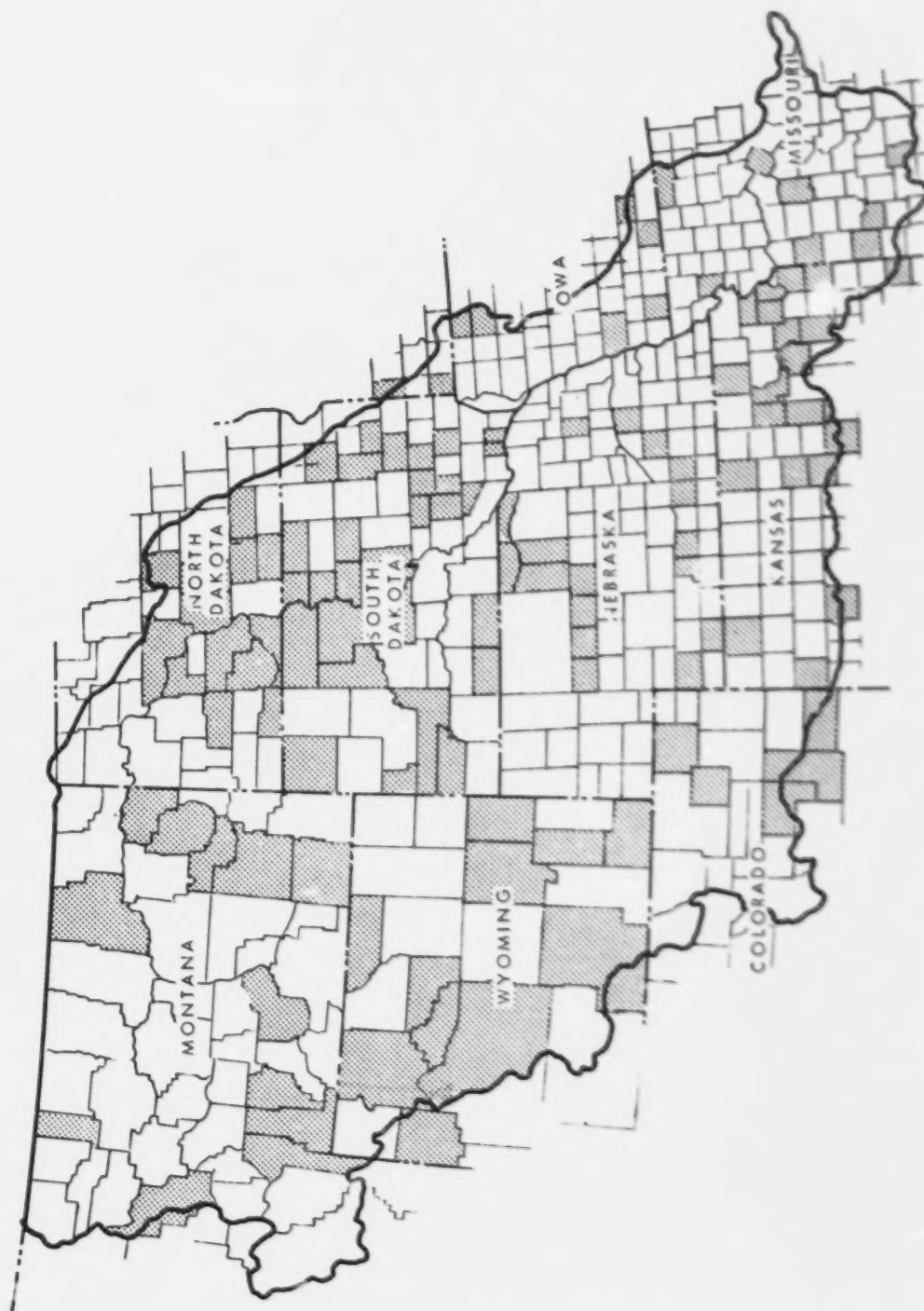


Figure A-1 - The Result of Pesticides Use Data Survey. The dotted counties are those that answered the questionnaire.

67

TABLE A-3

DATA SOURCES: MISSOURI

<u>Agency</u>	<u>Form</u>	<u>Data Coverage</u>	<u>Information</u>	<u>Amount</u>	<u>On Hand</u>	<u>Remarks</u>
USGS	"Water Resources Data," Part 1	Nationwide	Drainage Area, Daily Discharge Statistics	Extensive	All Basin States	
USGS	USGS Magnetic Tapes	Nationwide	Daily Discharge, Statistics	Extensive	None	The Best Hydrologic Data Storage Available
EPA	STORET	Nationwide	Daily Discharge, Statistics	Moderate	All Stations in Basin. Statistics	
River Forecast Center, M.D.	River Magnetic Tapes	Basinwide	Gage Rating Curve, Hydrograph	Extensive	None	
USGS	"Travel of Solutes in the Lower Missouri River"	From Yankton, South Dakota, to St. Louis, Missouri	Time of Travel of Solutes, Dispersion and Dilution of the River	Moderate	Yes	
USGS	"Low Flow Characteristics of Missouri Streams"	State of Missouri	Statistical Study of Low-Flow Information	Extensive	Yes	
USGS	"Stream Flow Characteristics in the USGS," 2 Parts	Basinwide	Stream Flow Duration, High and Low-Flow Variation Characteristics	Extensive	Yes	
USGS	Evaluation of the Stream Flow Data Program	The Basin States	Stream Flow Characteristics, Basin Characteristics, and Climatic Characteristics, and Relation Among Them, on the State Basis	Extensive	All the Basin States Except Minnesota	
Bureau of Reclamation	Tables, a List of Water Stations	Basinwide	The Stations for Which the Data Have Not Been Published	Moderate	Yes	
USGS	Tables	Basinwide	River Depth, Flow Velocity	Extensive	None	Not Published
USGS	Tables, and Magnetic Storage, "Tables of Information on Water Data"	Nationwide	Statistics of Surface Water Stations	Extensive	Basin	
State of Missouri	Maps, "Flood Plain Information"	Nationwide	Water Surface Profiles; Flood Plain Cross Sections	Extensive	Johnson County, Kans.	

DATA SUMMARY - MINNESOTA

TABLE A-4

No.	Author	Data Source	Information	Amount	On Hand	Remarks
1	1	National Weather Service	(1) Hourly Precipitation and Temperature for the First Order Localities; (ii) Daily Precipitation, Daily Maximum and Minimum Temperatures for all Stations; Snow Fall and Ice on the Ground for some Stations (iii) Monthly Summary; Yearly Summary.	Extensive	1964-1971 All Basin States	Excellent data
2	2	The Basin States	Precipitation Data	Extensive	Yes	
3	3	The Basin States	(i) Normal Annual Total Precipitation (ii) 24-yr. 24-Year Rainfall (iii) Monthly Distribution of Precipitation (iv) Temperature Distribution by Month (v) Direction and Mean Speed of Wind (Monthly), etc.	Moderate	Yes	
4	4	Basinwide	(i) Adjusted Average Annual Precipitation (ii) Multi-Average Precipitation Probabilities (iii) Annual Run-Off vs. Annual Precipitation, etc.	Extensive	Yes	Analysis for the Basinwide
5	5	Basinwide	(i) Snowfall and Break-Up Dates for Major Towns and Regions (ii) Average Number of Days per Winter Season in a Snow Condition (iii) Average Rate of Temperature Break-Up, etc.	Moderate	Yes	
6	6	Basinwide	(i) Mean Annual Precipitation (ii) Year, 24-yr. Precipitation Intensity (iii) Mean Minimum January Temperature, etc.	Moderate	All Basin States except Minnesota	Data were used to correlate with Circum 11-1 data
7	7	National Weather Service	Statistics Frequency and Intensity	Moderate	Yes	

DATA CATEGORY: LAND USE

TABLE A-5

<u>Agency</u>	<u>Format</u>	<u>Data Coverage</u>	<u>Information</u>	<u>Amount</u>	<u>On Hand</u>	<u>Remarks</u>
Soil Conservation Service	Tables, "Conservation Needs Inventory," 1958-1960	Nationwide	On the County Basis - Land Use and Conservation Treatment Needs; Statistics of Cropping Patterns with Yield and Projected Yield by Source Area, Soil Resource Groups, and Sub-basins; Public Lands Are Not Included.		All Basin States	
NRCA	Magnetic Tapes	Basinwide	The Above Inventory Plus Soil Classification	Yes		
Soil Conservation Service	Tables, Magnetic Tapes "Conservation Needs Inventory," 1958-1967	Nationwide	On the County Basis - Acreage in Major Uses and Acreage of Each Land Use Classified by Physical Problems Affecting Its Use, Estimates of Needs for Conservation Treatment. Public Lands are Not Included.	Extensive	All Basin States	
Bureau of the Census	Tables, Magnetic Tapes, "Status of Agriculture" 1959	Nationwide	For Each County, Number of Farms Land in Farms, the Land Use; Livestock and Poultry, Crops Harvested, Agriculture Chemical Used, Etc. Data Include 194 Statistics for Comparison With 1959 Figures.	Extensive	Magnetic Tapes, All Basin States	
NRCA	Working Papers "Land Resource Appendix"	Basinwide	On the Sub-Basin Basis - Areas of Land and Water, Land Ownership, Land Uses	Yes		
State Board of Agriculture	Tables, "State Cropland and Livestock Data" (Annual Publication)	State	Major Crop Acreage, Production Data and Livestock Data, by County	Extensive	All Basin States Except Minnesota	
USDA (ASIS)	Tables, Magnetic Tapes "Feed Grain and Wheat Yields," 1970, 1971	Nationwide	By County and by State, Detail Crop Acreage	Extensive	1970, Tables by State	

TABLE A-6

DATA CATEGORY: TOPOGRAPHIC

Agency	Form	Data Coverage	Information		Amount	On Hand	Remarks
			Scale	Elevation Contour Interval			
USGS	Topographical Maps	Nationwide	1:24,000 1:250,000 1:500,000	10 ft 50 ft 200 ft	Extensive	Clay County, Kansas	More Detailed Information Available from the State Agencies
USGS	"Missouri River Basin Condensed Tabulation of River Mileage and Drainage Area"	Basinwide	(i) Same locations (ii) Mileage Above the Mouth (iii) Noncontributing Area (iv) Drainage Area		Moderate	All Basin States Yes	
USGS	"Evaluation of Stream Flow Data Program"	Nationwide	Basin Characteristics in Terms of Drainage Area, Main Channel Slope, Forest Cover, Soil Infiltration Index, Etc.		Moderate	All Basin States Except Minnesota	Correlation of Stream Flow Characteristics with Basin and Climatic Characteristics
River Forecast Center, NOAA	"Area - Elevation Maps"	Mountainous Area in Colorado, Wyoming and Montana	Elevation vs. $\frac{1}{4}$ of Area Below or at Same Elevation		Extensive	Yellowstone River, Big Horn River	
USGS	Table, "Slopes of Small Drainage Areas"	Basinwide	For Drainage Area of Less Than 10 Sq Mi		Moderate	None	Information for Gaged and Ungaged Sites. Not Published
USGS	Tables	Basinwide	Drainage Area, Cross-Sectional Area of River Stream, River Bed Slope		Extensive	None	
Soil Conservation Service	Regional Maps "Conservation Needs Inventory" 1963-1967	Nationwide	Slope Percent Class of County		Extensive	Yes	

DATA CATEGORY: SOIL CLASSIFICATION

TABLE A-7

<u>Agency</u>	<u>Format</u>	<u>Data Coverage</u>	<u>Information</u>	<u>Amount</u>	<u>On Hand</u>	<u>Remarks</u>
NRAC	Tables and Maps "Infiltration Data"	Basinwide	Generalized Soil Infiltration Groupings, Infiltration Field-Plot Data, Infiltration Estimates From Hydrograph and Storm Analyses, and Infiltration Values Used in Design Flood Studies	Moderate	Yes	
NRAC	Magnetic Tapes	Basinwide	Soil Classification Correlated With the Land Use Survey From the Conservation Needs Inventory	Extensive	Yes	The Most Comprehensive and Systematic Soil Classification data Available for NRAC (According to Mr. Putman of NRAC)
NRAC (AEC)	"Soil Survey"	Nationwide	Soil Maps, Soil Laboratory Data, Land-Capability Interpretations, Soil-Woodland Interpretation, Engineering Use of Soil, etc.	Extensive		"Soil Survey" of Shawnee County, Kansas and "Published Soil Survey of the U.S."
NRAC (AEC)	Tables, Maps	Great Plains States	Soil Classification Based on Sediment Yield	Extensive	None (under preparation)	Capable of Extending to All Basin States
NRAC	Tables	Basinwide	Soil Index by Watershed	Extensive	All Basin States	
Soil Conservation Service	Magnetic Tapes, "Conservation Needs Inventory" (1964-1967)	Nationwide	County Soil Erosion Class	Extensive	All Basin States	

TABLE A-8

DATA CATEGORY: LIVESTOCK

<u>Agency</u>	<u>Format</u>	<u>Data Coverage</u>	<u>Information</u>	<u>Amount</u>	<u>On Hand</u>	<u>Remarks</u>
State Board of Agriculture	Tables, "State Cropland and Livestock Data"	State	Number of Animals (Cows, Beef Cattle, Hogs, Sheep, Poultry) of Each Type by Counties, Published Annually	Extensive	All Basin States	
USDA	"Agricultural Statistics"	Nationwide	Same, by States	Yes	Yes	
Bureau of Census	Tables, Magnetic Tapes "Census of Agriculture" 1969	Nationwide	Number of Animals, Inventory and Sales by County	Extensive	Magnetic Tapes, All Basin States	

DATA CATEGORY: PESTICIDES

TABLE A-9

<u>Agency</u>	<u>Formal</u>	<u>Data Coverage</u>	<u>Information</u>	<u>Amount</u>	<u>On Hand</u>	<u>Remarks</u>
USDA (A-73)	"The Pesticide Review" (Annual)	Nationwide	Gross Annual Production of Major Herbicides, Fungicides, and Pesticides; Some Data on State Level		Yes (1970)	
USDA	"Agricultural Statistics"	Nationwide	Total Production by Type		Yes	
State Extension Service	"Livestock Insect Control Recommendations"	Basinwide	Recommended Application Rates and Practices of Insecticides on Livestock		Yes (Kansas)	
State Extension Service	"Field Crop Insect Control Recommendations"	State	Recommended Application Rates and Practices of Insecticides on Field Crops		Yes (Kansas)	
State Extension Service	"Chemical Weed Control in Field Crops"	State	Recommended Application Rates and Practices of Herbicides on Field Crops		Yes (Kansas)	
State Extension Service	"Chemical Weed Control in Horticultural and Forestry Plants"	State	Recommended Application Rates and Practices of Herbicides on Horticulture and Forestry Plants		Yes (Kansas)	
USNC, Bureau of the Census	"Census of Agriculture"	Nationwide	Cost of Chemicals Used on Various Crops and Acres Treated for Insect and Weed Control, by Counties		Magnetic Tapes, All Basin States	
County Extension Service	"MRI Questionnaire"	Basinwide	Quantity of Pesticides Used in County, Names of the Most-Used Pesticides, and Events of Heavy Pest Infestations	Extensive	One third of Counties in the Basin	

DATA CATEGORY: FERTILIZER

TABLE A-10

Agency	Format	Data Coverage	Information	Amount	On Hand	Remarks
State Board of Agriculture	"Fertilizer Tonnage Report"	Basinwide	Consumption By County or State Spring and Fall		All Basin States	
USDA	"Agricultural Statistics"	Nationwide	Consumption by State of Four Major Categories of Fertilizers		Yes	
USDA (ASCS)	"The Fertilizer Supply"	Nationwide	Gross Production by Type, of Major Types of Fertilizers		Yes	
USDC, Bureau of the Census	Tables, Magnetic Tapes "Census of Agriculture" 1959	Nationwide	Cost and Amount of Commercial Fertilizers and Lime Used and Acres on Which Used, by County		Magnetic Tapes, All Basin States	

TABLE A-11

DATA CATEGORY: DEMOGRAPHIC

<u>Agency</u>	<u>Format</u>	<u>Data Coverage</u>	<u>Information</u>	<u>Amount</u>	<u>On Hand</u>	<u>Remarks</u>
Bureau of the Census	Magnetic Tapes, Tables	Nationwide	Population, Area, Income, and Other Economic Information	Extensive	Tables	
U.S. Water Resources Council	Tables, "Economic Activity in the U.S. by Water Resources Regions and Subareas, Historical and Projected 1979-2020."	Nationwide	Population, Income, Employment, and Other Economic Information	Extensive	Yes	

APPENDIX B

INDIVIDUAL CONTACTS

<u>Name</u>	<u>Organization</u>	<u>City, State</u>
Mr. N. Barbarossa	MBIAC	Washington, D.C.
Mr. K. F. Myers	MBIAC	Lincoln, Nebraska
Mr. P. L. Harley	Missouri River Basin Planning Office	Omaha, Nebraska
Mr. G. J. Karabatsos Mr. R. E. Burnett	Corps of Engineers	Omaha, Nebraska
Mr. Coop Mr. Philips	Corps of Engineers	Kansas City, Missouri
Mr. R. Johnson Mr. H. F. Mondschein	NOAA, River Forecast Center	Kansas City, Missouri
Mr. V. Hagarty Mr. W. D. Haggard	NOAA, U.S. Department of Commerce	Asheville, North Carolina
Mr. Balke	NOAA, U.S. Department of Commerce	Kansas City, Missouri
Mr. S. Conger Mr. P. Linderstruth	EPA, STORET	Washington, D.C.
Mr. D. B. Parke	EPA	Kansas City, Missouri
Mr. J. Keyes Mr. P. Gibbs	Bureau of Reclamation	Billings, Montana
Dr. I. A. Watson Mr. J. M. Ingles	Bureau of Reclamation	Denver, Colorado
Mr. R. D. Hockensmith	USDA	Washington, D.C.
Mr. J. Putman	Economic Research Service	Lincoln, Nebraska
Mr. H. Gunewald	SCS	Washington, D.C.
Mr. Walter Pool	U.S. Forest Service	Lincoln, Nebraska
Mr. R. W. Eikleberry	SCS	Lincoln, Nebraska

<u>Name</u>	<u>Organization</u>	<u>City, State</u>
Mr. D. White	EPA	Arlington, Virginia
Mrs. M. Mason	Iowa State University	Ames, Iowa
Mr. J. Towler	ASCS	Kansas City, Missouri
Mr. J. T. Breen	Bureau of the Census	Suitland, Maryland
Mr. E. A. Moulder Mr. Grogil	USGS	Denver, Colorado
Mr. S. W. Wiitala	USGS	Iowa City, Iowa
Mr. C. W. Lane Mr. P. Jordan Mr. A. M. Diaz Mr. E. R. Hedman	USGS	Lawrence, Kansas
Mr. C. R. Collier	USGS	St. Paul, Minnesota
Mr. A. Homyk Mr. Jeffrey	USGS	Rolla, Missouri
Mr. G. Pike	USGS	Helena, Montana
Mr. K. A. Mackichan	USGS	Lincoln, Nebraska
Mr. R. C. Williams	USGS	Bismarck, North Dakota
Mr. J. E. Powell Mr. O. Larimar	USGS	Huron, South Dakota
Mr. R. Cushman	USGS	Cheyenne, Wyoming
Mr. M. D. Edwards Mr. F. H. Pauszek	USGS	Washington, D.C.
Mr. Leman	Division of Game, Fish and Parks	Denver, Colorado
Mr. K. Webb	Water Pollution Control Commission	Denver, Colorado

<u>Name</u>	<u>Organization</u>	<u>City, State</u>
Mr. F. D. Rolf	Colorado Crop and Livestock Reporting Service	Denver, Colorado
Dr. G. M. Van Dyne	Colorado State University	Fort Collins, Colorado
	Colorado Soil Conservation Service	Denver, Colorado
Dr. Gakstatter	The State Hygienic Laboratory	Des Moines, Iowa
Mr. R. Schliekelman	Environmental Engineering Service	Des Moines, Iowa
Mr. R. H. Sutherland	Iowa Crop and Livestock Reporting Service	Des Moines, Iowa
	Iowa Soil Conservation Service	Des Moines, Iowa
Mr. J. Burris Mr. J. Stoltenberg	Department of Health, Sewage, and Water Treatment	Topeka, Kansas
Mr. R. Schoonover	Kansas Forestry, Fish and Game Commission	Pratt, Kansas
Mr. J. Reh	State Soil Conservation Service	Salina, Kansas
Mr. F. Mosier Mr. F. Hoover	ASCS	Manhattan, Kansas
	State Board of Agriculture	Topeka, Kansas
Mr. J. E. Pallesen	Kansas Crop and Livestock Reporting Service	Topeka, Kansas
Mr. Steps	State Water Commission	Topeka, Kansas
Dr. H. Jacob	Kansas Water Resources Research Institute	Manhattan, Kansas
Mr. R. Hyde	State Extension, KSU (Agronomist)	Manhattan, Kansas

<u>Name</u>	<u>Organization</u>	<u>City, State</u>
Mr. L. Brooks	State Extension, KSU (Agronomist)	Manhattan, Kansas
Mr. J. Geisler	Entomologist Forester	
Dr. O. W. Bidwell	Department of Agronomy, KSU	Manhattan, Kansas
Mr. F. Bieverly	Environmental Health Program, KU	Lawrence, Kansas
Mr. W. Campbell	Clay County Extension	Clay Center, Kansas
Mr. R. Davis	Johnson County Commission	Olathe, Kansas
Mr. T. Hall	Johnson County Extension	Olathe, Kansas
Mr. E. J. Sisk	Miami County Extension	Paola, Kansas
Mr. J. M. Lackey	Water Department Superintendent	Parsons, Kansas
Mr. A. W. Rumsev	Board of Public Utilities	Kansas City, Kansas
Mr. M. Calitueux	Water Pollution Control Plant	Kansas City, Kansas
Mr. C. C. Nitt	Water Department	Ottawa, Kansas
Mr. A. G. Lee	Water Works Department	Leavenworth, Kansas
Mr. C. E. Reynolds	Water Department	Topeka, Kansas
Mr. G. J. Boyd	Municipal Service	Russell, Kansas
	Soil Conservation Service	St. Paul, Minnesota
Mr. C. Stieffmann	Missouri Water Pollution Control Board	Jefferson City, Missouri
Mr. J. E. Smith		
Mr. D. Sayre	Missouri State Department of Health	Jefferson City, Missouri
Mr. J. W. Barrowman	Missouri Crop and Livestock Reporting Service	Columbia, Missouri

<u>Name</u>	<u>Organization</u>	<u>City, State</u>
Mr. J. V. Martin	Missouri Soil Conservation Service	Columbia, Missouri
Mr. J. H. Fondreu	Capital City Water Company	Jefferson City, Missouri
Mr. C. P. Wood	Water Treatment Plant	Jefferson City, Missouri
Mr. H. Marks	Kansas City Water Works	Kansas City, Missouri
Mr. C. Bennett	Chillicothe Municipal Utilities	Chillicothe, Missouri
Mr. C. H. Taylor	Sedalia Water Department	Sedalia, Missouri
Mr. R. Jackson	Pollution Control Department	Kansas City, Missouri
Mr. D. Taylor	Minnesota Crop and Live-stock Reporting Service	St. Paul, Minnesota
Mr. L. M. Lehn	Minnesota Department of Agriculture	St. Paul, Minnesota
Mr. D. G. Williams	State Department of Health	Helena, Montana
Mr. D. L. Herbert	State Statistical Office	Helena, Montana
Mr. Whitney	Department of Game, Fish, and Parks	Helena, Montana
	Soil Conservation Service	Bozeman, Montana
Dr. C. Smith	Agricultural Experiment Station, Montana State University	Bozeman, Montana
Dr. D. Larson	Economic Research Service, Montana State University	Bozeman, Montana
Mr. R. Langemeir	Nebraska Water Pollution Control Council	Lincoln, Nebraska
Mr. Foster	Department of Game, Fish, and Parks	Lincoln, Nebraska

<u>Name</u>	<u>Organization</u>	<u>City, State</u>
Mr. N. D. Beller	State-Federal Division of Agricultural Statistics	Lincoln, Nebraska
	Soil Conservation Service	Lincoln, Nebraska
Mr. V. Heavelen	North Dakota State	Bismarck, North Dakota
Mr. N. Peterson	Department of Health	
Mr. J. R. Price	North Dakota Crop and Livestock Reporting Service	Fargo, North Dakota
	Soil Conservation Service	Bismarck, North Dakota
Professor E. B. Vasey	State University Station North Dakota State University	Fargo, North Dakota
Mr. M. Allum	State Department of Health	Pierre, South Dakota
Mr. J. C. Ranok	South Dakota Crop and Livestock Reporting Service	Sioux Falls, South Dakota
	Soil Conservation Service	Huron, South Dakota
Mr. P. Carson	Plant Science Department South Dakota State University	Brookings, South Dakota
Mr. Williamson	State Office of Health, Education and Welfare	Cheyenne, Wyoming
Mr. D. Dexter	State Game and Fish Office	Cheyenne, Wyoming
Mr. L. J. Hoffman	Wyoming Cooperative Crop and Livestock Reporting Service	Cheyenne, Wyoming
Mr. R. C. Kronenberger	Soil Conservation Service	Casper, Wyoming
Mr. L. Bourret	Wyoming Department of Agriculture	Cheyenne, Wyoming
Professor H. W. Hough	Plant Science Division The University of Wyoming	Laramie, Wyoming

APPENDIX C

WATER QUALITY STATIONS SELECTED

MR1 Station Code	STORET Station Code	STORET Agency Code	Stream Name	Station Location
157001	06294000	112580	Little Bighorn	Hardin, Montana
158001	06306300	112580	Big Horn	Montana-Wyoming line
159000	06308301	112580	Longs	Mill, City, Montana
160001	06312300	112580	Boxelder	Lawson, Wyoming
160006	06317000	112580	Boxelder	Arvada, Wyoming
160011	06324300	112580	Boxelder	Morehead, Montana
161001	06333000	112580	St. J. Taylor	Harlem, Wyoming
162001	06334300	112580	Salt Creek	Shoshone, Wyoming
163001	06336400	112580	Travis Forks	Upper Goshute, Wyoming
163001	06336400	112580	Upper Fork	Arvada, Wyoming
164001	06460901	112580	Black Missouri	Camp Creek, South Dakota
165000	06460900	112580	Black	Sioux, North Dakota
166001	06460900	112580	Spring Creek	Map, North Dakota
167001	06472500	112580	Grand River	Sioux Falls, South Dakota
168001	06493000	112580	Chasson	Edgemont, South Dakota
169000	06493000	112580	Chasson	Highland, South Dakota
170001	06493000	112580	Chasson	Sioux, South Dakota
171001	06494000	112580	Chasson	Sioux Falls, Wyoming
172001	06494000	112580	Chasson	Sioux Falls, Wyoming
173001	06494000	112580	Chasson	Sioux Falls, Wyoming
174001	06494000	112580	Chasson	Sioux Falls, Wyoming
175001	06494000	112580	Chasson	Sioux Falls, Wyoming
176001	06494000	112580	Chasson	Sioux Falls, Wyoming
177001	06494000	112580	Chasson	Sioux Falls, Wyoming
178001	06494000	112580	Chasson	Sioux Falls, Wyoming
179001	06494000	112580	Chasson	Sioux Falls, Wyoming
180001	06494000	112580	Chasson	Sioux Falls, Wyoming
181001	06494000	112580	Chasson	Sioux Falls, Wyoming
182001	06494000	112580	Chasson	Sioux Falls, Wyoming
183001	06494000	112580	Chasson	Sioux Falls, Wyoming
184001	06494000	112580	Chasson	Sioux Falls, Wyoming
185001	06494000	112580	Chasson	Sioux Falls, Wyoming
186001	06494000	112580	Chasson	Sioux Falls, Wyoming
187001	06494000	112580	Chasson	Sioux Falls, Wyoming
188001	06494000	112580	Chasson	Sioux Falls, Wyoming
189001	06494000	112580	Chasson	Sioux Falls, Wyoming
190001	06494000	112580	Chasson	Sioux Falls, Wyoming
191001	06494000	112580	Chasson	Sioux Falls, Wyoming
192001	06494000	112580	Chasson	Sioux Falls, Wyoming
193001	06494000	112580	Chasson	Sioux Falls, Wyoming
194001	06494000	112580	Chasson	Sioux Falls, Wyoming
195001	06494000	112580	Chasson	Sioux Falls, Wyoming
196001	06494000	112580	Chasson	Sioux Falls, Wyoming
197001	06494000	112580	Chasson	Sioux Falls, Wyoming
198001	06494000	112580	Chasson	Sioux Falls, Wyoming
199001	06494000	112580	Chasson	Sioux Falls, Wyoming

<u>MRI</u> <u>Station</u> <u>Code</u>	<u>STORET</u> <u>Station</u> <u>Code</u>	<u>STORET</u> <u>Agency</u> <u>Code</u>	<u>Stream Name</u>	<u>Station Location</u>
5726001	06878500	112WRD	Lyons Creek	Woodbine, Kansas
5730001	06879900	112WRD	Big Blue	Surprise, Nebraska
5730006	00300924	21NEB001	Big Blue	Crete, Nebraska
5730011	06882400	112WRD	Big Blue	Oketo, Kansas
5730016	06887000	112WRD	Big Blue	Manhattan, Kansas
5731001	06880000	112WRD	Lincoln Creek	Seward, Nebraska
5732001	06880800	112WRD	W. Fork Big Blue	Dorchester, Nebraska
5733001	06881200	112WRD	Turkey Creek	Wilber, Nebraska
5734001	06883000	112WRD	Little Blue	Deweese, Nebraska
5734006	00301107	21NEB001	Little Blue	Gilrod, Nebraska
5734011	00301104	21NEB001	Little Blue	Fairbury, Nebraska
5734016	06884400	112WRD	Little Blue	Barnes, Kansas
5740001	06890400	112WRD	Delaware	Arrington, Kansas
5740006	00190191	112WRD	Delaware	Perry Res., Kansas
5750001	06891500	112WRD	Wakarusa	Lawrence, Kansas
5800001	06902000	112WRD	Grand	Sumner, Missouri
5810001	06899620	112WRD	Thompson	Chillicothe, Missouri
5900001	06905500	112WRD	Chariton	Prairie Hill, Missouri
6100001	00280955	21MOB001	Lamine	Pilot Grove, Missouri
6200001	00280943	21MOB001	Morcan	Jefferson City, Missouri
6300001	06916600	112WRD	Marais Des Cygnes	Kansas-Missouri Line
6300006	00280955	21MOB001	Swage	Warsaw, Missouri
6300011	00280957	21MOB001	Swage	St. Thomas, Missouri
6310001	06917000	112WRD	Little Swage	Fulton, Kansas
6311001	06917500	112WRD	Marmaton	Fort Scott, Kansas
6320001	00280963	21MOB001	Lee	Stockton, Missouri
6330001	00190278	112WRD	Wm. & Terr. R.	Worthington, Missouri
6340001	00280963	21MOB001	South Grand	Crack, Missouri
6400001	00280967	21MOB001	Lawrence	Warrens, Missouri

APPENDIX D

SELECTION OF IMPORTANT PARAMETERS

For the purpose of providing adequate streamflow information at any point on any stream, the U.S. Geological Survey has set up a nationwide program to study the streamflow characteristics by means of systems model approach. Both methodology adopted and result obtained in this program are published and are extremely useful to this project as an indication of important data parameters.

The statistical characteristics of streamflow can be defined by stream gauging, analytical methods of regionalization, systems studies, or any combination of these. Stream gauging at every site where information may be required is generally considered to be too expensive. However, cost of obtaining adequate information can be reduced by supplementing the information with regionalization and system studies.

The method adopted to regionalize streamflow characteristics for natural-flow streams is to relate them to basin and climate characteristics in equations developed to use multiple-regression techniques applied to historic data. The standard error of estimate of regression equations thus obtained can be used to judge the accuracy of estimation. The equation and its constants having been defined, streamflow characteristics for a specific site in a given basin can be computed by substituting the appropriate values of the hydrologic variables in the equation.

Tables D-1, D-2, and D-3, respectively, list streamflow parameters, drainage-basin physical parameters and climatic parameters considered in this program. Table D-4 presents regression equations for the basin states.

TABLE D-1

SUMMARY OF STREAMFLOW CHARACTERISTICS

<u>Symbol</u>	<u>Characteristic</u>	<u>Definition</u>
$M_{7,2}, M_{7,10}, M_{7,20}$	Low-flow	Annual minimum 7-day flows at 2-year, 10-year, and 20-year recurrence.
$Q_2, Q_5, \text{ etc.}$	Flood-peak	Discharge from the annual flood-frequency curve at recurrence intervals of 2, 5, 10, 25 and 50 years.
$V_{7,2}, V_{7,10}, V_{7,50}$	Flood-volume	Annual highest 7-day mean-flows at recurrence intervals of 2, 10, and 50 years.
Q_a	Mean-flow, annual	Mean-flow of the annual means.
Q_n	Mean-flow, monthly	Mean-flow for each calendar month, subscript "n" refers to the numerical order of the month beginning with January as 1.
SD_a	Flow-variability, annual	Standard deviation of annual mean.
SD_n	Flow-variability, monthly	Standard deviation of monthly means, subscript "n" refers to the numerical order of months with January as 1.

TABLE D-2

SUMMARY OF DRAINAGE BASIN PHYSICAL CHARACTERISTICS

<u>Symbol</u>	<u>Characteristic</u>	<u>Unit</u>	<u>Definition</u>
A	Drainage area	Square mile	Area measured in a horizontal plane, enclosed by a topographic divide from which direct surface runoff from precipitation normally drains by gravity into the stream above the specific point.
L	Main-channel length	Miles	The distance from the gauging station to the basin divide.
B	Main-channel slope	Percent	The river bed slope determined from the elevation at points 10% and 90% of the distance along the channel from the gauging station to the divide.
C	Mean basin elevation	Feet	Mean elevation for the basin above mean sea level.
F	Forest area	Percent	The percentage of forested area in total drainage area.
L_d	Area of lakes and ponds	Percent	The percentage of area of lakes and ponds in total drainage area.
I_p	Soil infiltration index	Inches	The value of potential maximum infiltration during an annual flood under average soil-moisture conditions.

TABLE D-3

SUMMARY OF DRAINAGE BASIN CLIMATIC CHARACTERISTICS

<u>Symbol</u>	<u>Characteristics</u>	<u>Unit</u>	<u>Definition</u>
P	Mean annual precipitation	Inches	
P _n	Mean monthly precipitation	Inches	Mean precipitation for each calendar month, sub- scription "n" refers to the numerical order of months with January as 1.
P _{24,2}	Rainfall intensity	Inches	The maximum 24-hr rainfall having a recurrence interval of 2 years.
P _{24,50}	Rainfall intensity	Inches	The maximum 24-hr rainfall having a recurrence interval of 50 years.
E _v	Evaporation	Inches	Mean annual evaporation in basin.
S _n	Snowfall index	Inches	The water equivalent of snow on ground 1-15 March, with 10% probability.
T ₁	Mean minimum January temperature	°F	
T ₃	Mean maximum March temperature	°F	
T ₇	Mean maximum July temperature	°F	

TABLE D-4

SUMMARY OF REGRESSION ANALYSES OF MEAN ANNUAL FLOW

Region	Equation	Standard Error of Estimate, %	Remarks
Colorado			
-Mountains Region	$Q_a = 0.00140 A^{0.956} S_t^{0.192} p^{2.101} T_l^{0.189}$	47	
Kansas	$Q_a = 0.106 A^{0.947} (P-14.0)^{1.613} E_v^{-0.771}$	28	
Missouri			
-Plains Region	$Q_a = 0.037 A^{0.983} P_{24,2}^{2.70} S_i^{-0.511}$	10.6	
-Plateau Region	$Q_a = 0.288 A^{1.10} (F+1)^{0.124}$	27.5	
Montana			
-Region A	$Q_a = 0.000344 A^{0.900} (E/1000)^{4.91} F^{0.430}$ $p^{0.555} E^{-1.14}$ $6,000$	31	$E_{6,000}$ = Area above 6,000 ft ft elevation, %
-Region B	$Q_a = 0.0522 L^{1.47} E^{0.613}$ $6,000$	53	
-Region C	$Q_a = 0.002 A^{0.937} S_t^{0.406} F^{0.581} p^{0.889}$ $p^{1.61} E^{0.103}$ $24,2$ $6,000$	27	
Nebraska			
-Sand Hills Region	$Q_a = 0.0175 L^{1.23} S^{0.499} S_i^{1.19} D_s^{0.405}$	33	D_s = A special index developed for Sand Hills Streams
-Outside the Sand Hills Region	$Q_a = 0.0484 A^{1.55} A_c^{-0.540} F^{0.197} p^{1.65}$ $E_v^{-0.954} S_h^{-1.70}$	31	A_c = Contributing drainage area, square miles
North Dakota	$Q_a = 0.54 A^{0.975} S^{0.360} (E_y - 12)^{-1.363}$ $(T_3 - 26)^{1.176} S_h^{0.359} (F + 0.01)^{0.084}$	61	S_h = Basin shape factor, a ratio of length to the width

TABLE D-4 (Concluded)

SUMMARY OF REGRESSION ANALYSES OF MEAN ANNUAL FLOW

<u>Region</u>	<u>Equation</u>	<u>Standard Error of Estimate, %</u>	<u>Remarks</u>
South Dakota -James River Basin	$Q_a = 4.59 \times 10^{-6} A^{0.951} S_n^{4.342} E_v^{1.283}$	66.2	
-the remaining portion of the state	$Q_a = 6.11 \times 10^{-3} A^{1.002} F^{0.224} I_{2.24}^{1.916} S_n^{0.624}$	72.7	
Iowa	$Q_a = 0.00341 A^{1.01} S_t^{-0.123} F^{0.051} (P-20)^{0.788}$ $\cdot P^{0.261} (T_7-80)^{-0.294} S_i^{0.366}$ 24.2	15	
Wyoming	$Q_a = 3.12 \times 10^{-5} A^{0.97} S_t^{0.56} E^{1.64} P^{1.78} Lat^{0.76}$	27	Lat = Latitude of the center of the drainage basin, in decimal form, less 40.0°.

APPENDIX E

MRI STATION AND RIVER CODES

The water quality stations selected in this program were operated by 10 different agencies, and each agency has its own coding system. To facilitate easy identification a special MRI coding system was designed.

The MRI station code has seven digits, the first five comprise the river code and the last two are the station number. From the code, we can tell on which river the station is located and its relative location to other stations along that river.

The River Code

The five-digit river code (Table E-1) is a specific number assigned to each stream for the identification of: (1) stream rank; and (2) stream number. The stream rank is indicated by the number of digits in the code, which are other than zero. These nonzero digits are assigned from left to right, with higher nonzero digits for higher rank streams. The Missouri River main stem is ranked one and is coded with one nonzero digit (code 10000). Rivers flowing directly into the Missouri River are ranked two and are coded with two nonzero digits (e.g., the Sun River: 14000). Rivers of other ranks are coded in the same manner.

The stream numbers are assigned consecutively in the downstream direction. Based on the observer looking downstream, the first river encountered is given a number 1 (the last nonzero digit). The next river encountered is given a number 2, etc. In general, we have less than 10 rivers in a single tributary. Therefore, a single digit has been sufficient to indicate the stream number. The exception is the Missouri River, to which more than 50 secondary streams are tributaries. The stream numbers for these tributaries are given by the numbers 11 to 64 with deletion of the numbers 20, 30, 40, 50, and 60, each of which would indicate a stream of rank one. For example, the code for the Milk River is 21000 instead of 20000 which would indicate a stream rank equivalent to that of the Missouri River.

Furthermore, MRI River Code 14000 given to the Sun River, indicates that: (1) it is a second-rank stream (two nonzero digits); and (2) it is the fourth tributary (from upstream) encountered by a river of the next higher rank (the Missouri River).

Station Number

The two-digit station number is assigned also in the downstream direction. The first station is given the number 01, the second station is given 06, etc., each time with five higher than the previous number to leave space for the addition of new stations.

The combination of River Code (at right) and Station Number constitutes the MRI Station Code. For example, Station 2500006 is the second station (06) on River 25000 (the Yellowstone River). Appendix C lists the codes for all the selected stations.

TABLE E-1

RIVER CODE
MISSOURI RIVER BASIN

<u>River</u>	<u>Code</u>	<u>Tributary</u>
Missouri River	10000	
Jefferson River	11000	Montana
a. Bedrock River	11100	Montana
b. Beaverhead River	11200	Montana
c. Ruby River	11300	Montana
d. Big Hole River	11400	Montana
e. Boulder River	11500	Montana
f. Madison River	11600	Montana
Gallatin River	12000	Montana
Smith River	13000	Montana
Sun River	14000	Montana
Marias River	15000	Montana
a. Two Medicine Creek	15100	Montana
b. Outbank Creek	15200	Montana
c. Willow Creek	15300	Montana
d. Teton River	15400	Montana
Arrow River	16000	Montana
Judith River	17000	Montana
Musselshell River	18000	Montana
a. Boxelder Creek	18100	Montana
Dry Creek	19000	Montana
Milk River	21000	Montana
a. Big Sandy Creek	21100	Montana
1. Sago Creek	21110	Montana
b. Peoples Creek	21200	Montana
c. White Water Creek	21300	Montana
d. Frenchman River	21400	Montana
e. Beaver Creek	21500	Montana
f. Rock Creek	21600	Montana
Redwater Creek	22000	Montana
Poplar River	23000	Montana
Big Muddy Creek	24000	Montana
Yellowstone River	25000	Wyoming, Montana, North Dakota
a. Shields River	25100	Montana
b. Stillwater River	25200	Montana
c. Clarks Fork	25300	Wyoming, Montana
d. Pryor Creek	25400	Montana

TABLE E-1 (Continued)

<u>River</u>	<u>Code</u>	<u>Tributary</u>
e. Big Horn River	25500	Wyoming, Montana
1. Wind River	25510	Wyoming
(a) Popo Agie (Little Wind) River	25511	Wyoming
2. Muskrat Creek	25520	Wyoming
3. Badwater Creek	25530	Wyoming
4. Nowood Creek	25540	Wyoming
5. Greybull River	25550	Wyoming
6. Shoshone River	25560	Wyoming
(a) North Fork Shoshone River	25561	Wyoming
7. Little Big Horn River	25570	Montana
f. Rosebud Creek	25600	Montana
g. Tongue River	25700	Wyoming, Montana
h. Powder River	25800	Wyoming, Montana
1. South Fork Powder River	25810	Wyoming
2. Middle Fork Powder River	25820	Wyoming
3. Salt Creek	25830	Wyoming
4. Crazy Woman Creek	25840	Wyoming
5. Clear Creek	25850	Wyoming
6. Little Powder River	25860	Montana
i. O'Fallon Creek	25900	Montana
Little Muddy Creek	26000	North Dakota
Little Missouri River	27000	Montana, South Dakota, North Dakota
a. Boxelder Creek	27100	Montana
Knife River	28000	North Dakota
a. Spring Creek	28100	North Dakota
Heart River	29000	North Dakota
Apple Creek	31000	North Dakota
Cannonball River	32000	North Dakota
a. Cedar Creek	32100	North Dakota
Beaver Creek	33000	North Dakota
Grand River	34000	North Dakota, South Dakota
a. North Fork Grand River	34100	North Dakota
b. South Fork Grand River	34200	South Dakota
Moreau River	35000	South Dakota

TABLE E-1 (Continued)

<u>River</u>	<u>Code</u>	<u>Tributary</u>
Cheyenne	36000	Wyoming, South Dakota, Nebraska
a. South Fork Cheyenne River	36100	Wyoming
b. Lance Creek	36200	Wyoming
c. Beaver Creek	36300	South Dakota, Wyoming
d. Hat Creek	36400	South Dakota, Nebraska
e. Belle Fourche River	36500	Wyoming, South Dakota
1. Redwater Creek	36510	South Dakota
f. Cherry Creek	36600	South Dakota
Bad River	37000	South Dakota
White River	38000	South Dakota, Nebraska
a. South Fork White River	38100	South Dakota
Ponca Creek	39000	South Dakota, Nebraska
Noiabrara River	41000	Nebraska, South Dakota
a. Kayapaha River	41100	South Dakota, Nebraska
James River	42000	North Dakota, South Dakota
a. Pepestem Creek	42100	North Dakota
b. Elm River	42200	South Dakota
c. Mud Creek	42300	South Dakota
d. Snake Creek	43400	South Dakota
e. Turtle Creek	42500	South Dakota
f. Redstone Creek	42600	South Dakota
Vermillion River	43000	South Dakota
Big Sioux River	44000	South Dakota, Iowa, Minnesota
a. Rock River	44100	Iowa, Minnesota
Floyd River	45000	Iowa
Little Sioux River	46000	Iowa, Minnesota
a. Maple River	46100	Iowa
Soldier River	47000	Iowa
Papillion Creek	48000	Nebraska
Platte River	49000	Colorado, Wyoming, Nebraska
a. North Platte River	49100	Colorado, Wyoming, Nebraska
1. Medicine Bow River	49110	Wyoming
(a) Rock Creek	49111	Wyoming
(b) Little Medicine Bow River	49112	Wyoming

TABLE E-1 (Continued)

<u>River</u>	<u>Code</u>	<u>Tributary</u>
2. Sweetwater River	49120	Wyoming
3. Laramie River	49130	Wyoming, Colorado
(a) Little Laramie River	49131	Wyoming
4. Rawhide Creek	49140	Wyoming
5. Horse Creek	49150	Wyoming, Nebraska
6. Pumpkin (Pumpkinseed) Creek	49160	Nebraska
b. South Platte River	49200	Colorado, Nebraska, Wyoming
1. South Fork South Platte River	49210	Colorado
2. Bear Creek	49220	Colorado
3. Cherry Creek	49230	Colorado
4. Clear Creek	49240	Colorado
5. St. Vrain Creek	49250	Colorado
(a) Boulder Creek	49251	Colorado
6. Big Thompson River	49260	Colorado
7. Lache la Poudre River	49270	Colorado
8. Lodgepole Creek	49280	Nebraska, Wyoming
c. Wood River	49300	Nebraska
d. Loup River	49400	Nebraska
1. South Loup River	49410	Nebraska
2. Middle Loup River	49420	Nebraska
(a) Dismal River	49421	Nebraska
3. North Loup River	49430	Nebraska
(a) Calamus River	49431	Nebraska
4. Cedar River	49440	Nebraska
e. Elkhorn River	49500	Nebraska
1. Logan Creek	49510	Nebraska
2. Maple Creek	49520	Nebraska
f. Salt Creek	49600	Nebraska
1. Wahoo Creek	49610	Nebraska
Nishnabotna River	51000	Iowa, Missouri
a. East Nishnabotna	51100	Iowa
Little Nemaha River	52000	Nebraska
Nemaha River	53000	Missouri, Kansas, Nebraska
Tarkio River	54000	Iowa, Missouri
Nodaway River	55000	Iowa, Missouri

TABLE E-1 (Continued)

<u>River</u>	<u>Code</u>	<u>Tributary</u>
Platte River	56000	Iowa, Missouri
a. One Hundred and Two River	56100	Iowa, Missouri
Kansas River	57000	Colorado, Nebraska, Kansas
a. Republican River	57100	Colorado, Nebraska, Kansas
1. North Republican River	57110	Colorado, Nebraska, Kansas
(a) Arikaree River	57111	Colorado, Nebraska
2. South Republican River	57120	Colorado, Kansas
3. Frenchman Creek	57130	Colorado, Nebraska
(a) Stinking Water Creek	57131	Colorado, Nebraska
4. Redwillow Creek	57140	Nebraska
5. Medicine Creek	57150	Nebraska
6. Sappa River	57160	Colorado, Nebraska Kansas
(a) North Fork Sappa River	57161	Kansas
(b) South Fork Sappa River	57162	Kansas
(c) Beaver Creek	57163	Colorado, Nebraska, Kansas
7. Prairie Dog Creek	57170	Kansas, Nebraska
8. Buffalo Creek	57180	Kansas
b. Smoky Hill River	57200	Colorado, Kansas
1. Beaver (Ladder) Creek	57210	Colorado, Kansas
2. Hockberry Creek	57220	Kansas
3. Big Creek	57230	Kansas
4. Saline River	57240	Kansas
(a) Paradise Creek	57241	Kansas
5. Soloman River	57250	Kansas
(a) North Fork Soloman River	57251	Kansas
(b) South Fork Soloman River	57252	Kansas
6. Lyon Creek	57260	Kansas
c. Big Blue River	57300	Nebraska, Kansas
1. Lincoln Creek	57310	Nebraska
2. West Fork, Big Blue	57320	Nebraska
3. Turkey Creek	57330	Nebraska
4. Little Blue River	57340	Nebraska, Kansas

TABLE E-1 (Concluded)

<u>River</u>	<u>Code</u>	<u>Tributary</u>
d. Delaware River	57400	Kansas
e. Wakarusa River	57500	Kansas
Grand River	58000	Iowa, Missouri
a. Thompson River	58100	Iowa, Missouri
Chariton River	59000	Iowa, Missouri
Lamine River	61000	Missouri
a. Blackwater River	61100	Missouri
Moreau River	62000	Missouri
Marias de Cygnes-Osage River	63000	Kansas, Missouri
a. Little Osage River	63100	Kansas, Missouri
l. Marmaton River	63110	Kansas, Missouri
b. Sac River	63200	Missouri
c. Pomme de Terre River	63300	Missouri
d. South Grand River	63400	Missouri
e. Niangua River	63500	Missouri
Gasconade River	64000	Missouri

APPENDIX F

MAPS SHOWING COUNTY-WATERSHED RELATIONSHIPS
FOR SUBBASINS 31 THROUGH 42

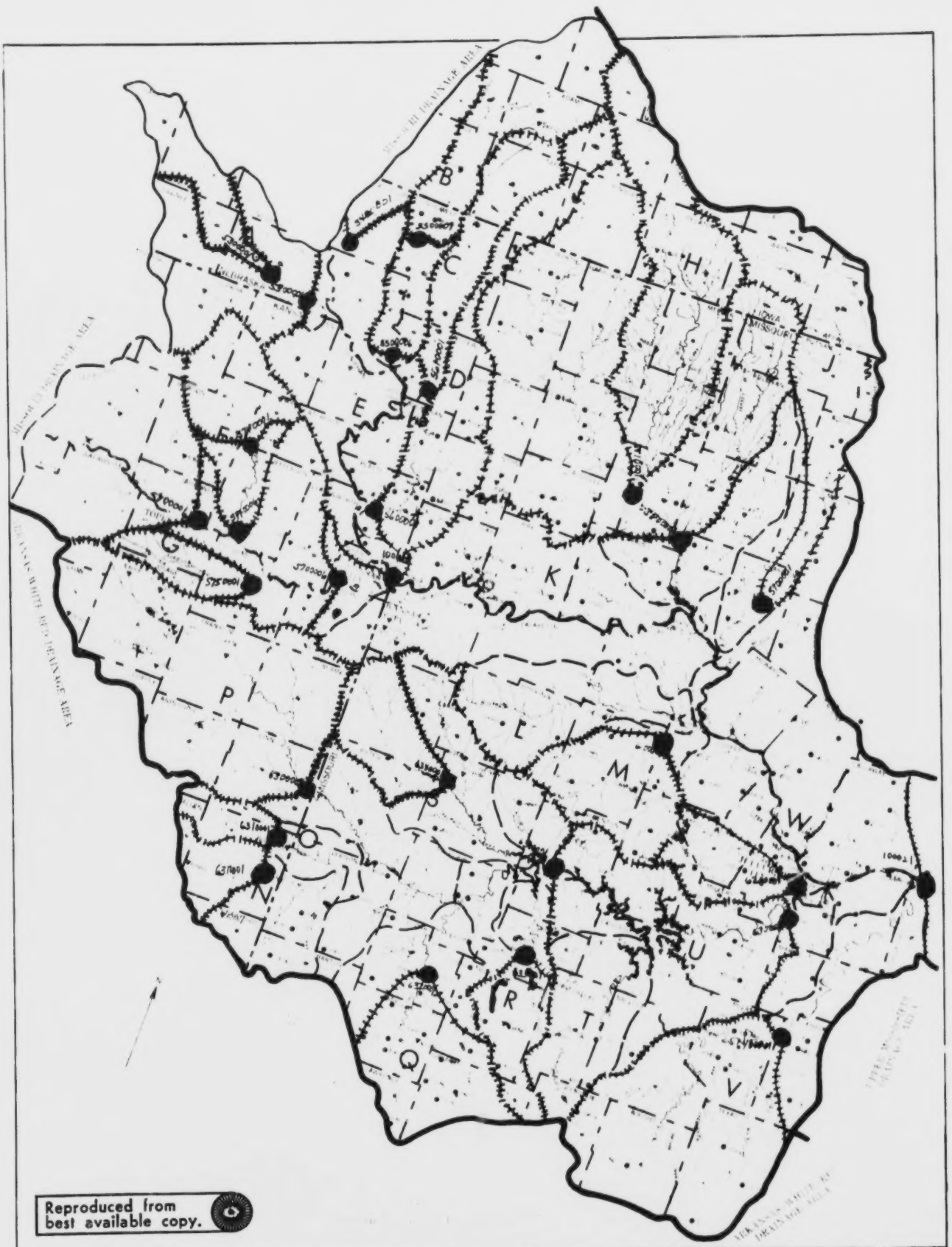


Figure F-1 - Subbasin 31

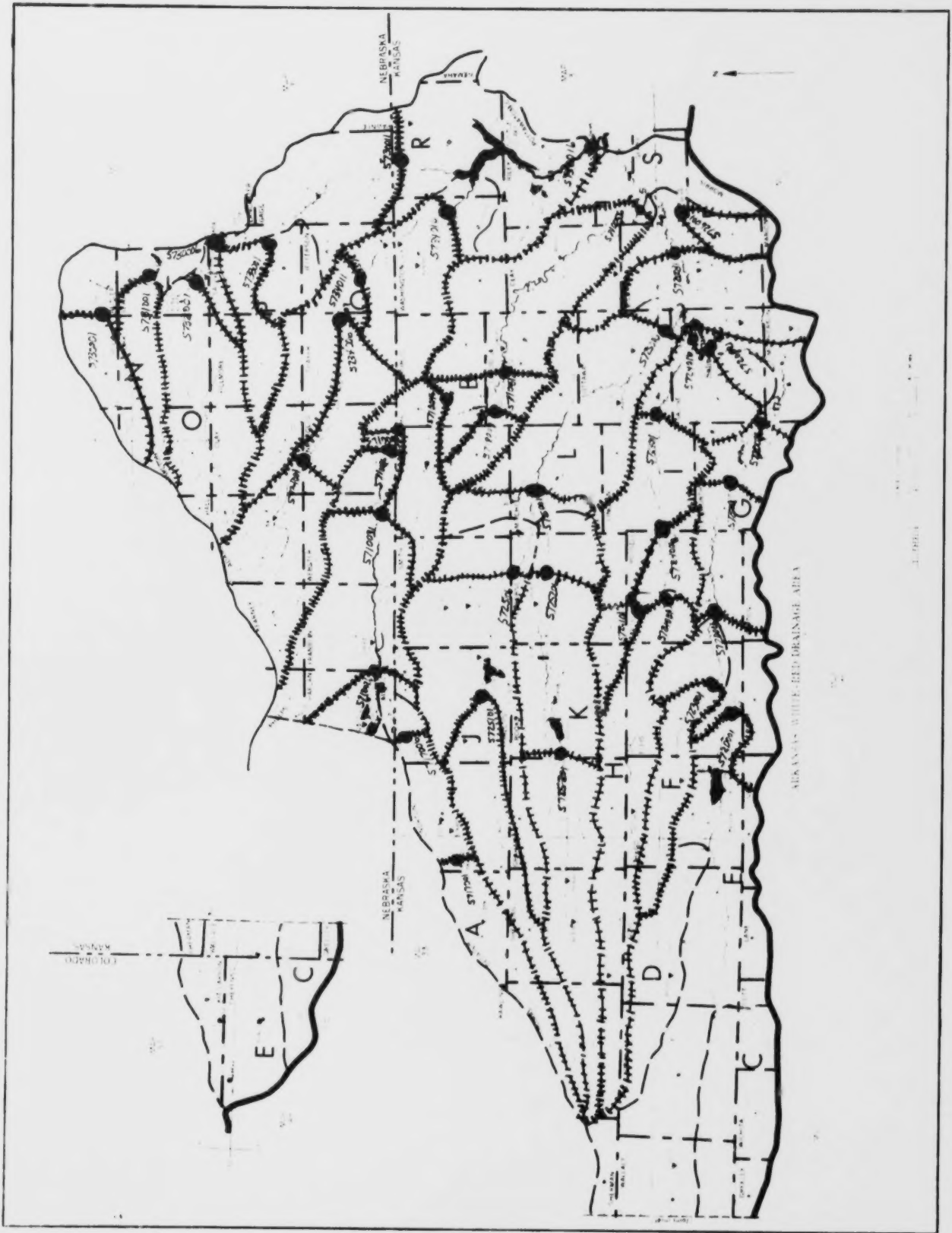


Figure F-2 - Subbasin 32



Figure F-3 - Subbasin 33

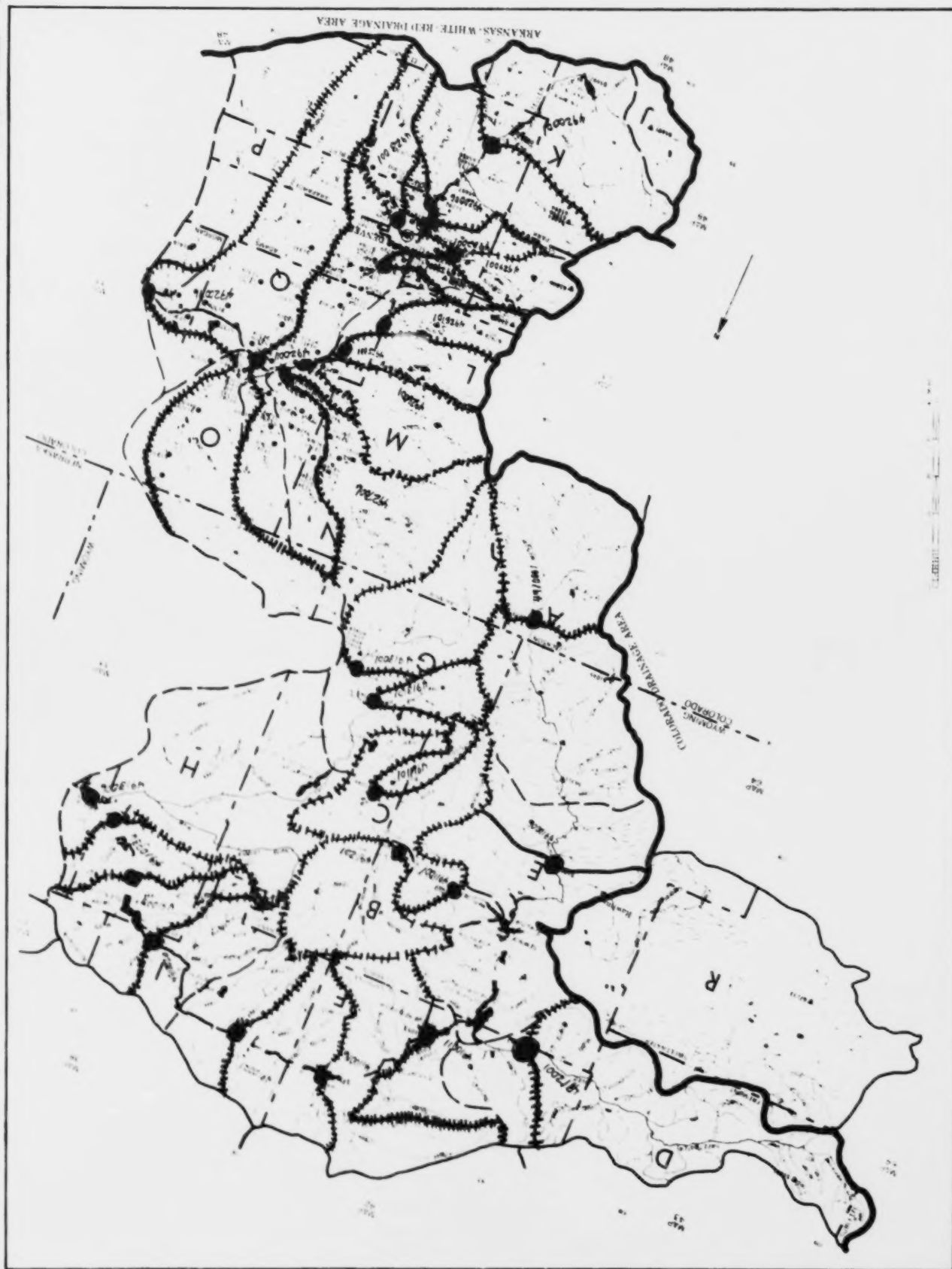


Figure F-4 - Subbasin 34

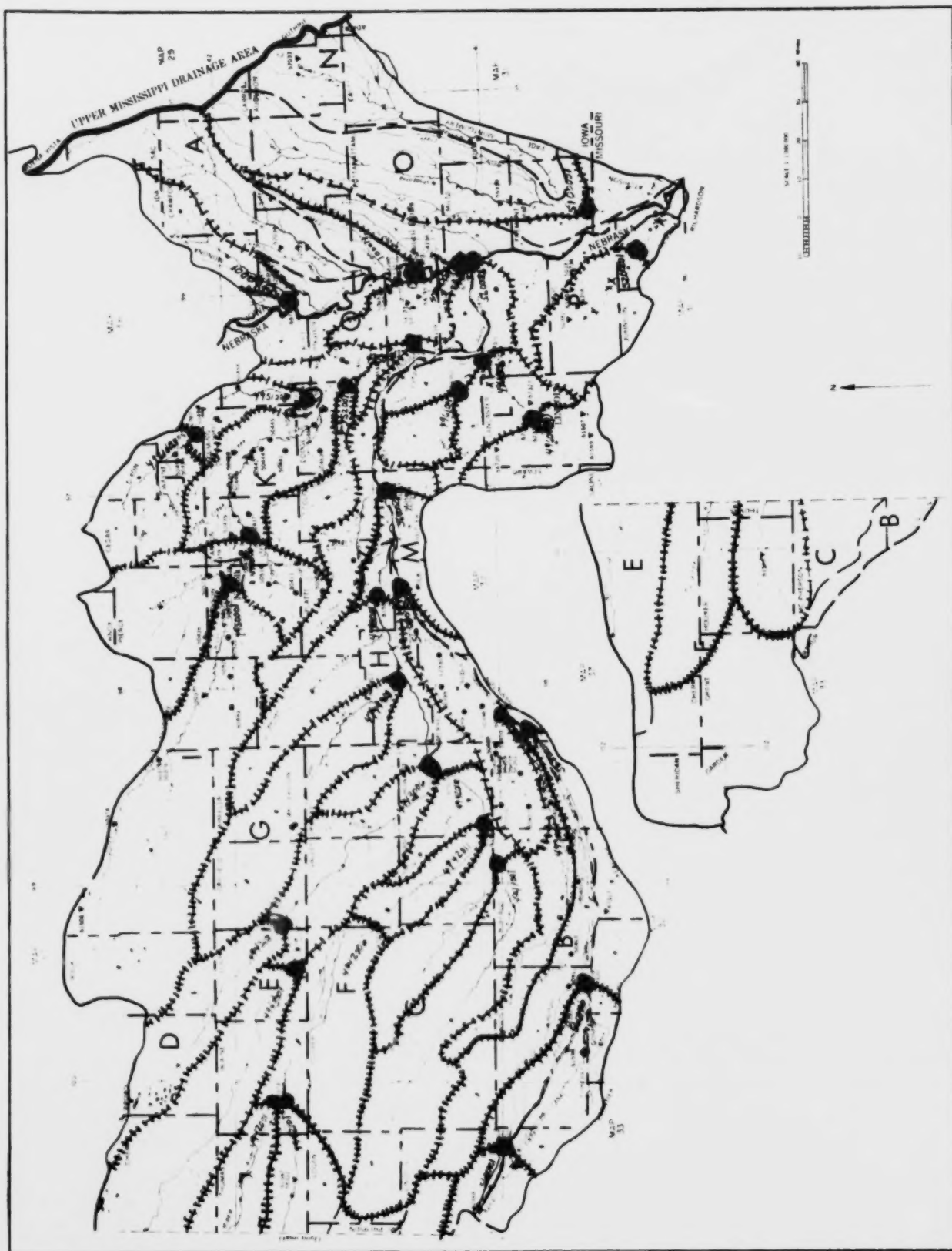


Figure F-5 - Subbasin 35

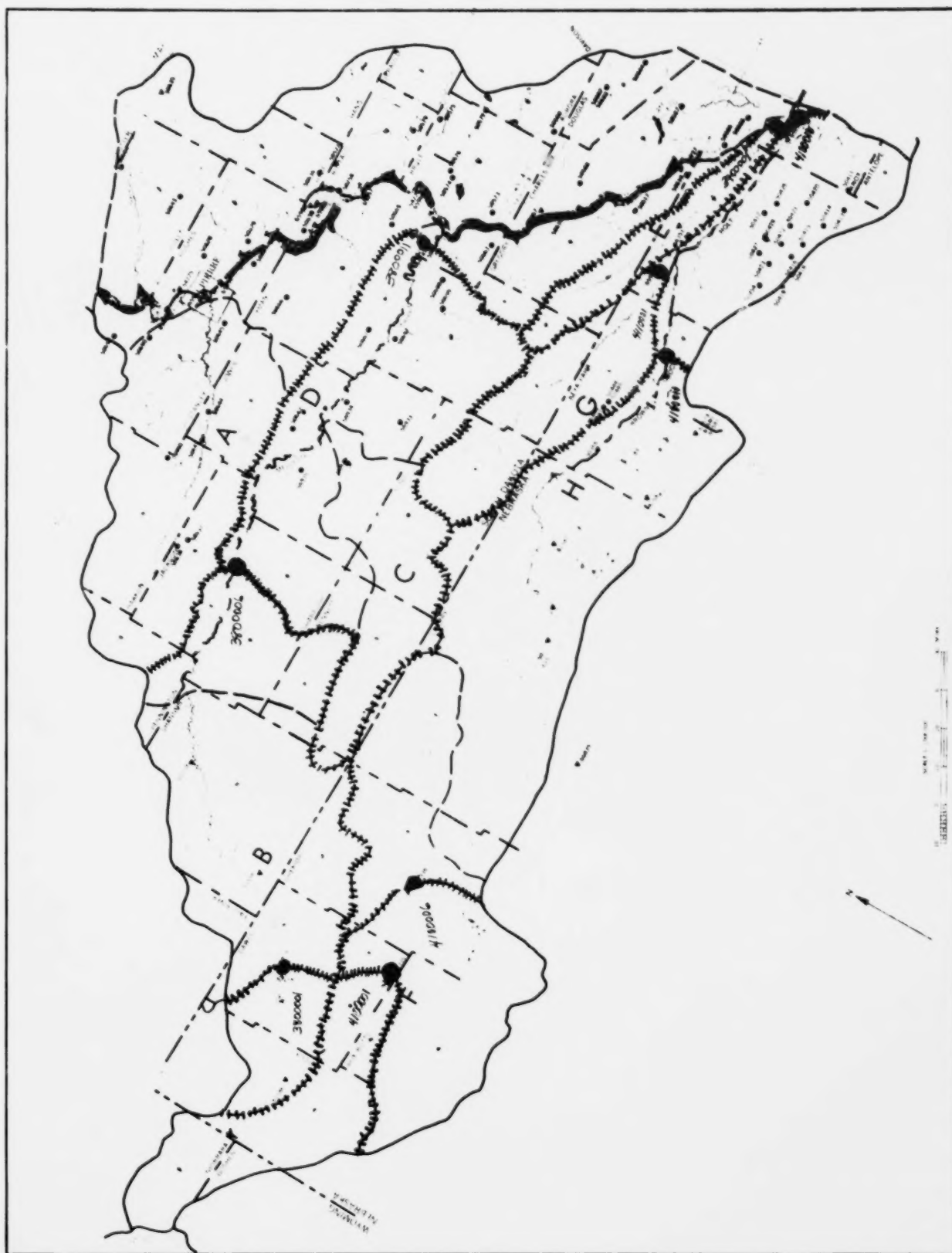
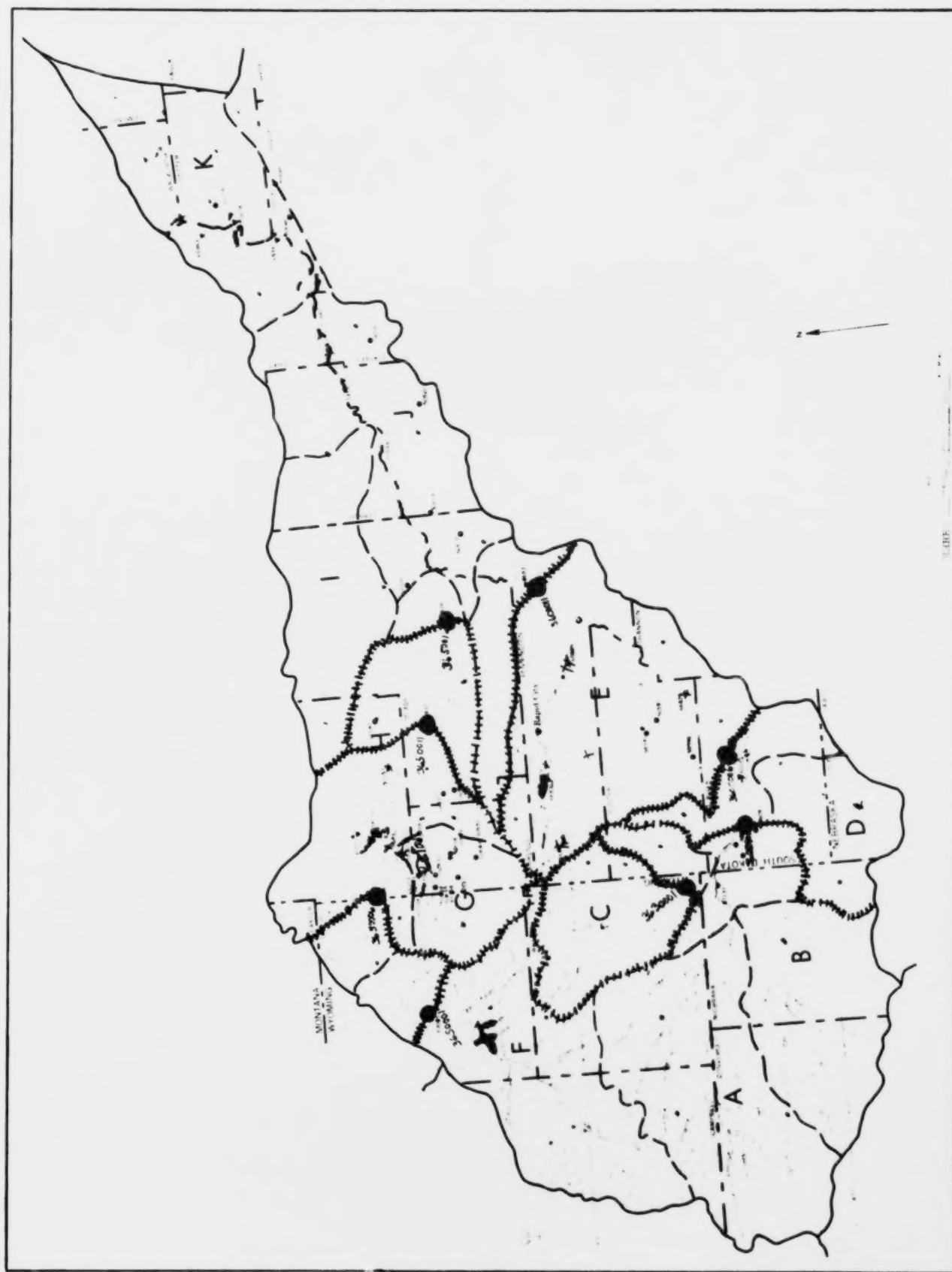


Figure F-7 - Subbasin 37



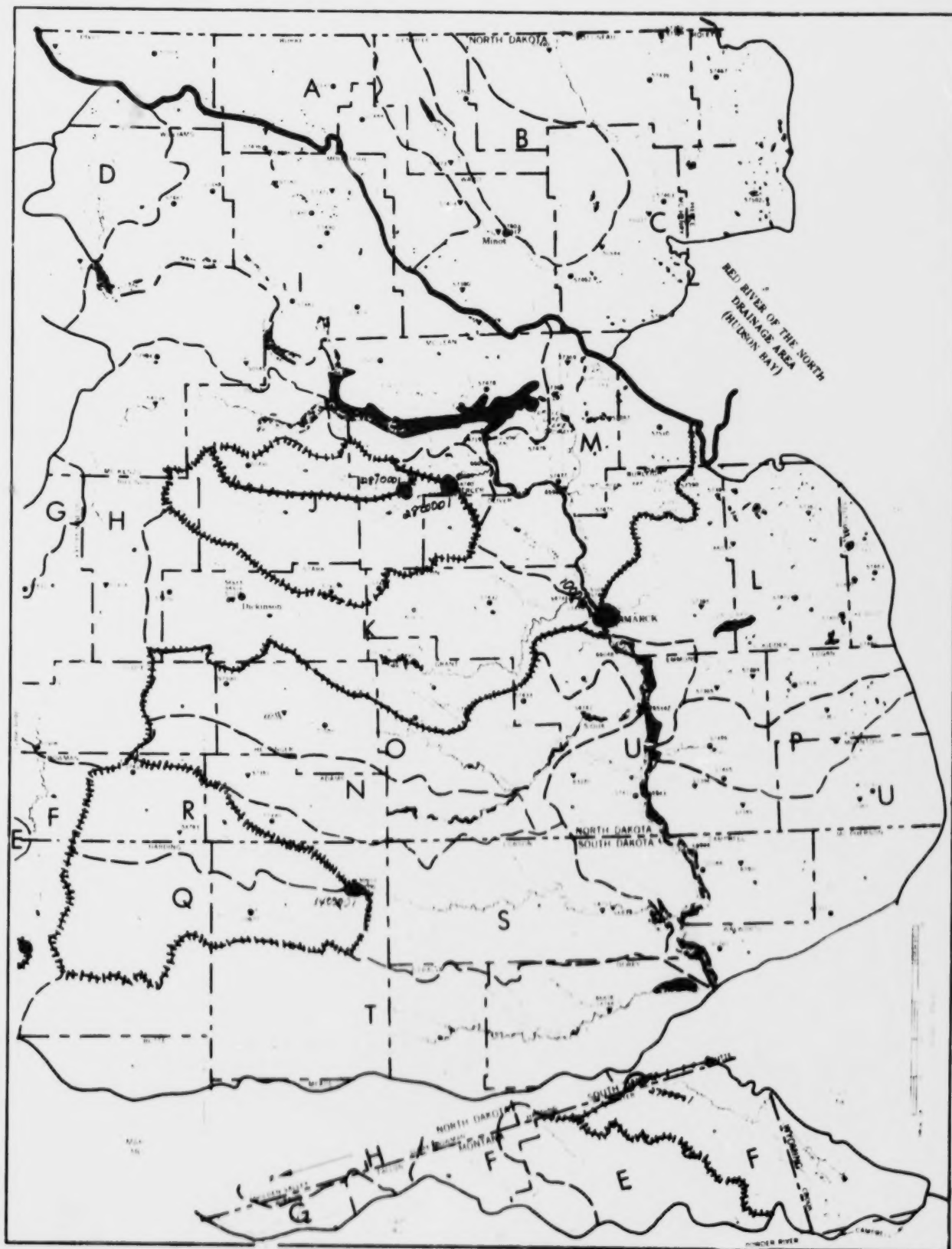


Figure F-9 - Subbasin 39

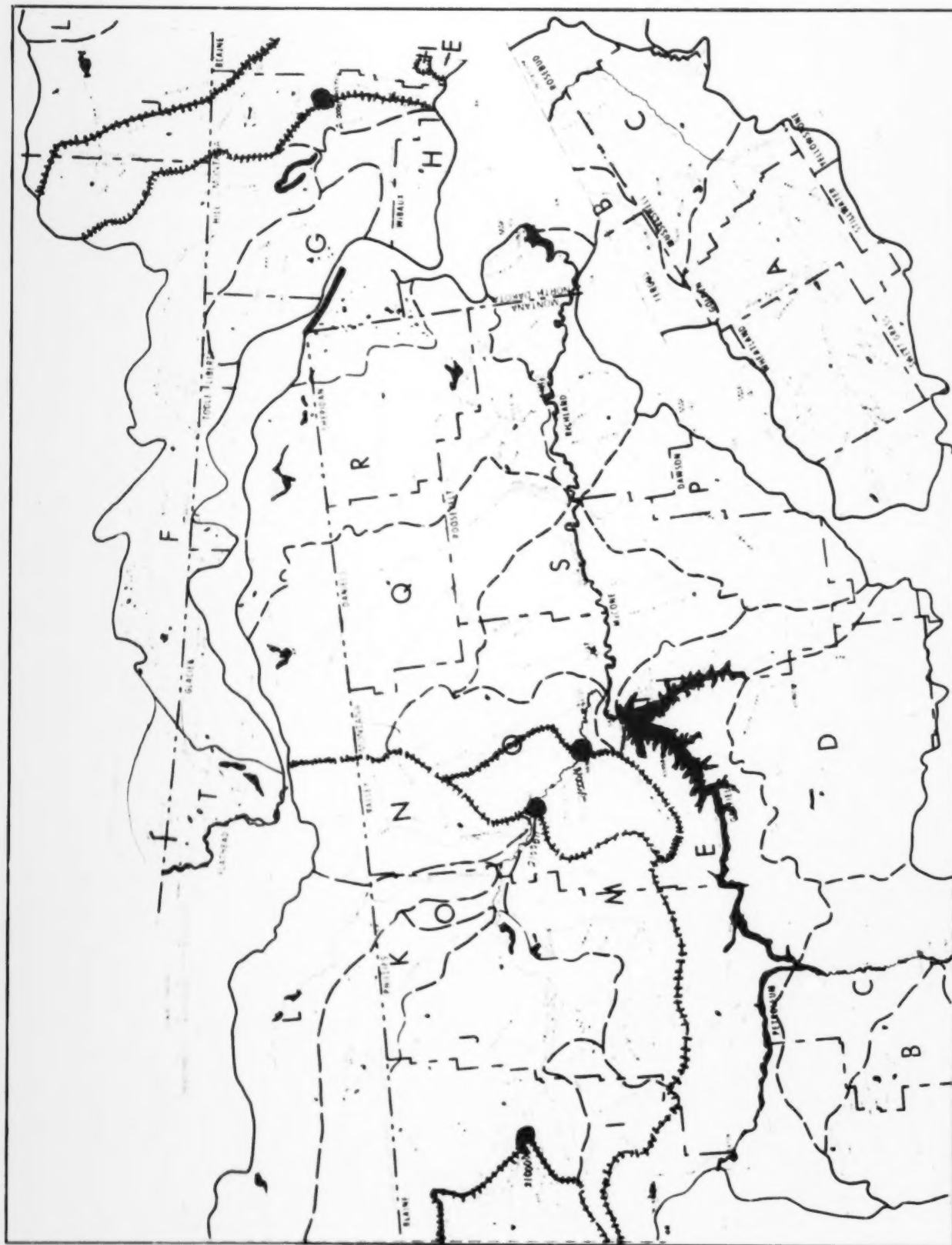


Figure F-10 - Subbasin 40

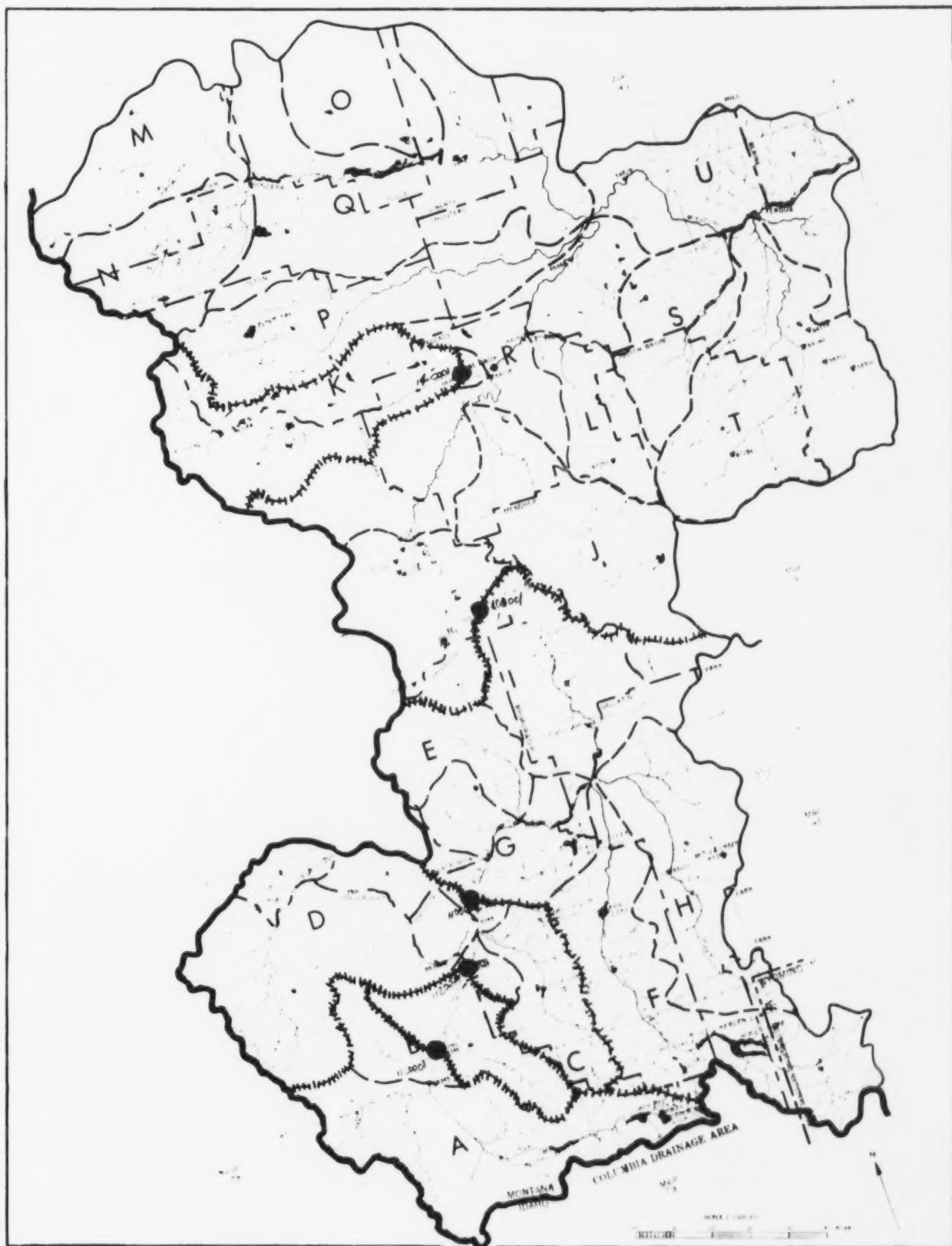


Figure F-11 - Subbasin 41



Reproduced from
best available copy.

Figure F-12 - Subbasin 42